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Evaluating economic feasibility and maximization of social welfare of photovoltaic projects developed for the Brazilian northeastern coast: An attribute agreement analysis

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ABSTRACT

Recently, renewable energy projects, such as photovoltaic systems, have become interesting generation alternatives thanks to the incentive strategies developed by several countries. For the user of photovoltaic microgeneration, there is interest in the financial return of the investment, which is most often financed by public banks with a limited budget. Therefore, it is necessary to analyze variables related both to the point of view of the investor in microgeneration and to the public banks that subsidize them. However, defining the configuration of photovoltaic systems that guarantees the economic feasibility for those who invest without excessively burdening the public resource is a complex task and requires the analysis of different experts. To fill this gap, this paper proposes an innovative approach for evaluating photovoltaic projects based on Attribute Agreement Analysis. Experts on photovoltaic systems with different profiles and experience were asked about 16 scenarios, planned according to a factorial design with four factors: installed power capacity, PV cell type, debt ratio, and loan interest rate. The results demonstrated that the proposed approach fulfills the objective of simultaneously assessing the impact of investments in photovoltaic systems, considering the investors' and public banks' viewpoints. In the case analyzed, although the evaluations are performed in a judicious way ($W_{within} > 0.85$), there is a low agreement between the experts ($W_{overall} < 0.70$). In addition, an expert bias was observed regarding loan interest for economic feasibility ($W = 0.61$), as well as a controversial perception of the maximization of social welfare ($W = 0.2361$). The Net Present Value profile, determined by the installed power capacity of the system, was used with these results to discuss the current Brazilian renewable energy financing policy. The results supported that experts tend to overestimate the impact of the financing interest rate on financial returns.

1. Introduction

Renewable energy sources (RES) are recognized as a good alternative to the use of fossil fuels since they contribute to mitigating the emission of greenhouse gases that are harmful to the atmosphere [1–3]. As energy demand grows due to technological progress and human development, Wong et al. [4] explain that it has become a priority for many countries to adopt policies and strategies to encourage RES, especially in the area of electricity generation. However, RES still faces barriers such as the high technological cost and lower technological efficiency compared to conventional sources [5].

To overcome these barriers, several countries have mainly used the so-called long-term strategies, thus favoring a greater insertion of RES in the generation of electricity [6]. These strategies aim to attract investors to produce electricity from RES, and, according to Abdomoulleh et al. [7] and Aquila et al. [8], the main strategies are:

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Nomenclature

a	Number of levels of a factor in a factorial design
B	Project risk regarding the market
CF_t	Cash flow at a certain time
D	Debt
E	Equity
$E_{p_{FV}}$	Photovoltaic potential energy
I_m	Average irradiation in the period
i	Discount rate
k	Number of factors in a factorial design or number of categories of a scale
n	Project lifespan, number of ratings per subject or number of subjects
N	Total number of runs or subjects
σ^2	Variance
P_o	Observed mean proportion of agreement
P_e	Expected mean proportion of agreement
p, x_{ij}	Number of appraisers
p_j^2	Expected proportion of agreement for each category
R_i	Ranks
r_b	Brazil risk premium
r_f	Risk free rate
r_m	Expected market return
T	Average of ratings to tied observation
t	Investigated time
t_k	Number of tied ranks in each group of ties
τ	Kendall's correlation coefficient
W	Kendall's coefficient of concordance

Abbreviations

AAA	Attribute Agreement Analysis
ANEEL	Brazilian Electricity Regulatory Agency
BNDES	Brazilian Development Bank
CAPM	Capital Asset Pricing Model
DOE	Design of Experiments
GR&R	Gage Repeatability and Reproducibility
ICMS	Tax on Commerce and Services
MSA	Measurement System Analysis
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
PV	Photovoltaic
RES	Renewable Energy Sources

- Feed-in tariffs: are based on the guarantee of fixed remuneration for each type of RES generation through long-term contracts and the guarantee of access to the network [9];
- Quotas/Renewable Portfolio Standards: regulators determine a portion of the energy to be produced through RES, which must be achieved by agents that produce and consume energy. Less efficient agents in meeting targets can buy green certificates of the most efficient [10].
- Auctions: consists of establishing a quantity or budget for the contracting of electricity produced through RES and in conducting auctions where generally the projects with the lowest costs are contracted [11,12].
- Net Metering: This is based on the total or partial compensation of each unit of energy supplied to the network by an agent installing a microgeneration system called prosumer [13,14].

Due to the liberalization of the power grid in many countries, one generation model that has become attractive is distributed generation through small-scale systems [15]. In these systems, the consumer has the possibility of generating part or all of the energy consumed and becoming a prosumer. Although this generation model is attractive to many families [16], support schemes are needed to make technology cheaper in the long run and to attract prosumers financially; in this context, net metering strategies have been an important and very popular long-term strategy to leverage the growth of photovoltaic (PV) microgeneration in several locations [17]. In net metering, compensation occurs through the use of a meter that shows the generation balance in relation to consumption at the end of a certain period. From that balance, the prosumer's remuneration is accounted for [8,18].

Ayoub and Yuji [8] add that to maximize the benefits of long-term strategies, regulators may also resort to short-term strategies. Direct subsidies to the production chain, tax exemption, collection of fees on agents that do not meet clean generation targets and special financing lines are examples of short-term RES strategies.

Given that RES generation projects are capital-intensive [19], any strategies that facilitate initial investment in technology for generation are welcome, whether long-term or short-term. However, while such strategies help make this type of generation more feasible for investors, the regulator still faces a major challenge in managing a limited budget, especially in developing countries, where subsidies and loans from public banks for RES are practically indispensable. In this sense, identifying the projects that most need more attractive financing conditions has not been an elementary task and has generated many controversies between experts.

Analyzing the impact of strategic support schemes is relevant for both the investor, who wants to make financial gains from RES electricity generation, and the policy maker, whose challenge is to design policies that are not rejected by society. In the literature, these aspects have been dealt with separately. The study by Katsaprakakis and Christakis [20], for example, highlights the relevance of considering socioeconomic aspects to make RES support schemes successful. According to the aforementioned authors, the absence of regulation and strategic design allowed the granting of RES generation projects that violate environmental and cultural restrictions in Greece. In this sense, the authors investigate the main negative aspects in the regulatory framework for supporting RES in Greece, as well as propose measures for RES development in the country, combining the viability of investments and environmental protection in the country.

Lee et al. [21] analyze the investor's point of view from the economic and financial impact of support schemes on the return on investments in residential PV systems in the USA. To this end, 16 scenarios were suggested with different proposals for support schemes and tax subsidies that could make the investments in the systems more financially attractive. Results indicate that certain tax incentives and financial subsidies may stimulate new investments in residential PV systems in the USA.

In turn, other studies highlight the planning of RES electricity systems, considering the economic and environmental viewpoints, but without highlighting the challenges of policy makers in conducting support schemes. The studies of Shezan et al. [22], Shezan et al. [23], Shezan and Pingand [24], and Shezan and Das [25], for example, propose configurations for hybrid systems that use different RES combined with diesel generators. These studies seek to meet a certain level of demand and peak load for electricity in communities. Therefore, the proposals are based on simulation and optimization from Homer® software and field data related to climate variables, such as solar radiation, wind speed, and biomass potential. The results provide a configuration in which the leveled cost of energy to be met and the target of reducing greenhouse gas emissions are optimized.

1.1. Photovoltaic microgeneration in Brazil

Brazil is one of the countries with great potential for PV microgeneration due to the high solar radiation index throughout its territory [34]. However, the country's experience with the net metering for distributed generation only began in 2012, with the creation of normative resolution 482/2012, published by the Brazilian Electricity Regulatory Agency (ANEEL), which establishes the compensation system in micro and mini-generations for individual prosumers or companies wishing to save on electricity costs based on network feedback [26].

Currently, Brazilian standards state that microgeneration is characterized by systems with power up to 75 kW. In turn, mini-generation is characterized by systems with power between 75 kW and 5 MW [27]. It is also worth mentioning that Brazilian net metering supports the following sources: hydro, PV, wind, and biomass, as well as cogeneration systems. Thus, users of these micro and mini generation systems can be credited to reduce the value of the energy bill as compensation for the excess energy injected into the grid [28,29].

Since 2015, in order to complement the support of net metering in the dissemination of micro and mini-generation systems, some Brazilian states have adhered to the so-called *Convênio ICMS 16*. The agreement establishes the exemption of the Tax on Commerce and Services (ICMS) by the distributors to the owners of the micro and mini-generation systems [30,31].

In addition to this complementary strategy, in 2018, the Brazilian Development Bank (BNDES) launched a new line of subsidized loans for individuals, aiming at the acquisition of PV generation systems. This financing line appears at an opportune time to leverage microgeneration in the country since one of the gaps for microgeneration growth was the absence of appropriate microgeneration financing lines [32,33].

1.2. Risk mitigation in photovoltaic projects

While policies to support RES are beneficial in attracting investments in clean generation technologies, some care is needed to ensure that these strategies are not burdensome for some stakeholders. In Brazil, distributors are not prepared to accommodate large amounts of generation in the distribution systems [26] and have opposed the ICMS exemption and defended a greater payment for access to the distribution network for the use of distributed generation.

In other countries, some programs based on feed-in tariffs have also been questioned. Mabee et al. [35] explain that in the province of Ontario, Canada, an excessive level of remuneration for PV energy resulted in higher energy tariffs for the final consumer, which led the feed-in tariff program to be criticized by the local population. Jacobs et al. [36] also present examples from several countries in Latin America and the Caribbean that faced regulatory and budgetary constraints that caused the discontinuation of feed-in tariff programs.

In order to minimize the risk of establishing RES programs that are becoming unsatisfactory, it is necessary to engage with stakeholders and experts to understand the different points of view. The visions of these agents can be quite distinct and controversial, leading to complex decision making. The discussion process becomes relevant because, on the one hand, the role of microgeneration financing is to attract new prosumers to use the PV microgeneration system and, on the other hand, the public bank's budget for financing is limited, especially in developing countries. Hence, it is central to offer financing conditions compatible with the characteristics of the project to be considered so as not to allow extraordinary financial returns for a single investor.

In this context, understanding the experts' viewpoints becomes essential. Therefore, the present study proposes a new approach that seeks to evaluate the consensus among experts about the characteristics that make PV systems economically attractive for the prosumer. To this end, six experts are consulted to evaluate different configurations of a small-scale PV system installed in a district in northeastern Brazil. The characteristics considered in the assessment include: levels of power installed, PV cell type, debt ratio, and BNDES loan interest rates.

The main scientific aspect of this research is to analyze the impact of support schemes for RES microgeneration, considering both the investors' and the public banks' viewpoints. For this, the authors produced 16 scenarios for PV systems according to a factorial design, which was evaluated twice by the experts, with an interval of one month between the submissions. The experts were asked to assign scores between 0 and 5 for each of the designed scenarios for economic feasibility and maximization of social welfare. The evaluations were submitted to an Attribute Agreement Analysis (AAA), which provided the results presented in this study. Through the AAA, the experts and response variables were compared and discussions were made, based on the indexes Fleiss' Kappa and Kendall's W and τ. Importantly, although the object of this study is photovoltaic microgeneration, the same approach can be applied to other types of RES microgeneration, including hybrid systems.

This paper is organized as follows: Section 2 presents the statistical techniques and mathematical tools used in conducting this study, involving the Design of Experiments (DOE), the Gage R&R studies and the indexes Fleiss' Kappa and Kendall's W and τ used in the AAA. Section 3 presents the materials and methods used in conducting the study. Following, Section 4 presents the results and discussions. Finally, Section 5 presents the major conclusions of the present work.

2. Literature review

2.1. Design of experiments and factorial designs

In general, experiments are costly and very time consuming, even when financial resources are not involved, the research process is required to be the most efficient as possible. In this context, the design of experiments (DOE) techniques has been used in order to allow experiments with minimum resource consumption.

In addition, DOE techniques are, indeed, ways to better capture the main aspects of an investigated problem [37,38]. According to Montgomery [39], the DOE refers to planning an experiment so that the data are collected correctly and analyzed by statistical methods, resulting in valid conclusions.

Montgomery [39] suggests that DOE is applied according to the following steps:

1) Define the problem;
2) Choose the factors and their levels;
3) Choose the response variables;
4) Choose the experimental design;
5) Perform the experiments;
6) Analyze the collected data; and
7) Conclude and recommend.

Regarding the types of experimental design, Myers and Montgomery [40] explain that the main DOE techniques are full factorial design, fractional factorial design, Taguchi orthogonal arrays, response surface methodology, and mixture designs. Although these DOE techniques are widely used in the process and product improvement [41–45], they are also particularly important in Measurement System Analysis (MSA).

Gage Repeatability and Reproducibility (GR&R) studies, for example, is a designed experiment known as "factorial" [46]. A factorial design is a set of combinations of factor levels. A full factorial design provides all possible combinations of levels of the factors. Then, the total number of runs (N) is obtained as a function of the number of factors (k) and their levels (a). Mathematically,

$$N = a^k \tag{1}$$

The total number of runs (N) of a two-level full factorial design, considered the most important factorial design [39], is obtained by Eq. (2):

$$N = 2^k \tag{2}$$

2.2. Measurement System Analysis

Designed to measure the quality of industrial measurement systems, the GR&R studies combine different statistical techniques in order to classify these systems as acceptable, marginal or unacceptable [47,48]. For this reason, the GR&R studies are often known as capability analysis of measurement systems [49].

A measurement system shall be considered capable (or acceptable) if the measurement variance is very low in relation to the variance of the production process. Otherwise, the measurement system will be considered incapable (or unacceptable) or reasonably capable (or marginal), depending on the level of variability accepted by the customer [46,50].

GR&R studies, therefore, are widely used for continuous measurements, obtained by an equipment's readings, such as rugosimeters [51], reflectometers [52,53], and image analyzers [48]. In these cases, the main idea of GR&R studies is that the variance of the measurements can be decomposed into two components, one of the production process ($\sigma^2_{product}$) and another of the measurement system (σ^2_{gage}):

$$\sigma^2_{total} = \sigma^2_{product} + \sigma^2_{gage} \tag{3}$$

Based on this idea, the variance of the measurement system can also be decomposed into two components, one of repeatability ($\sigma^2_{\text{repeatability}}$), which refers to the variability observed when the measurement is repeated under identical conditions (the same operator, for instance), and one of reproducibility ($\sigma^2_{\text{reproducibility}}$), which refers to the variability observed when the measurement is repeated under different conditions (different operators, for instance):

$$\sigma^2_{gage} = \sigma^2_{repeatability} + \sigma^2_{reproducibility} \tag{4}$$

There are situations, however, where the gage set consists of expert evaluations rather than equipment meters. In these cases, the data collected are usually described by discrete variables, since evaluations can only assume a certain set of values [46].

For this type of problem, the literature recommends the use of Attribute Agreement Analysis (AAA), which employs Kappa statistics and Kendall's coefficients. Kappa statistics are particularly suitable for analyzing nominal data such as right/wrong, good/bad, low/medium/high, etc. [54]. These statistics measure the degree of agreement between the ratings and standard or between different ratings and can be calculated according to the Fleiss's schemes [55,56]:

$$Kappa = \frac{P_o - P_e}{1 - P_e} \tag{5}$$

$$P_o = \frac{1}{Nn(n-1)}\left(\sum_{i=1}^{N}\sum_{j=1}^{k} x_{ij}^2 - Nn\right) \tag{6}$$

$$P_e = \sum_{j=1}^{k} p_j^2 \tag{7}$$

$$p_j^2 = \left[\frac{1}{Nn}\left(\sum_{i=1}^{N} x_{ij}\right)\right]^2 \tag{8}$$

where: P_o is the observed mean proportion of agreement, p_j^2 is the expected proportion agreement for each category, P_e is the expected mean proportion of agreement, N is the total number of subjects, n the number of ratings per subject, k is the number of categories into which assignments are made and x_{ij} is the number of appraisers who assigned the *ith* subject to the *jth* category.

Kendall's coefficients, on the other hand, are particularly suitable for analyzing ordinal data such as Likert scale scores [57] or rankings [58]. When the appraisers are compared to each other (inter-appraisers evaluations) and to themselves (intra-appraisers evaluations), Kendall's coefficient of concordance (W), which measures the degree of association between the evaluations, should be used, according to the formulations below [59,60]:

$$W = \frac{12\sum_{i=1}^{n} R_i^2 - 3p^2 n(n+1)^2}{p^2(n^3 - n) - pT} \tag{9}$$

where: n is the number of subjects, $\sum_{i=1}^{n} R_i^2$ is the sum-of-squares statistic over the sums of ranks R_i, p is the number of appraisers and T assigns the average of ratings to tied observation:

$$T = \sum_{k=1}^{m}\left(t_k^3 - t_k\right) \tag{10}$$

in which t_k is the number of tied ranks in each (k) of m group of ties.

When appraisers are compared to a standard, Kendall's correlation coefficient (τ), which measures the degree of association between evaluations and a given standard should be used according to the following formulations [61]:

$$\tau = \frac{C - D}{\sqrt{([n_{++}(n_{++} - 1)0.5 - T_X][n_{++}(n_{++} - 1)0.5 - T_Y])}} \tag{11}$$

where: $T_X = 0.5\sum_i n_{i+}(n_{i+} - 1)$, n being the number of tied observations in each group of ties on the X variable, $T_Y = 0.5\sum_j n_{+j}(n_{+j} - 1)$, n being the number of tied observations in each group of ties on the Y variable, C is the number of concordant pairs $\sum\sum_{i<kj<l} n_{ij}n_{kl}$, D is the number of discordant pairs $\sum\sum_{i<kj>l} n_{ij}n_{kl}$, n_{i+} is the number of observations on the X variable, n_{+j} is the number observations on the Y variable, and n_{++} is the number of samples ranked on both X and Y.

Kappa statistic and Kendall's correlation coefficient can vary between −1 and 1 and Kendall's coefficient of concordance can vary between 0 and 1. Table 1 summarizes the agreement indexes and Fig. 1 illustrates the acceptability levels of agreement according to some references [47,62]. In all cases, the higher the agreement index, the better the evaluation system is considered.

Applications of AAA can be found in different branches of knowledge. Mejdell et al. [63], for instance, investigated the agreement of 43 students in the diagnosis of physical injuries in horses. The analysis was performed according to a scoring system of five categories. The students were asked to classify 40 photographs twice in random order with a

Table 1
Summary of agreement indexes.

Agreement Index	Range	Interpretation
Kappa statistic	−1 to 1	Kappa = 1: Perfect agreement Kappa = 0: Agreement is the same as expected by chance Kappa = −1: Agreement is less than expected by chance
Kendall's coefficient of concordance (W)	0 to 1	Kendall's coefficient = 1: Perfect association Kendall's coefficient = 0: No association
Kendall's correlation coefficient (τ)	−1 to 1	Kendall's coefficient = 1: Positive association Kendall's coefficient = 0: No association Kendall's coefficient = −1: Negative association

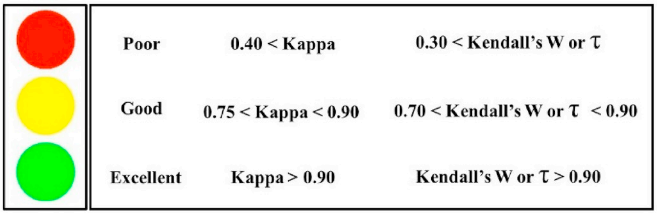

Fig. 1. Acceptability levels of agreement.

10-day interval. Fleiss' Kappa, *Kendall's τ* and Kendall's *W* were then employed to assess the reliability of the diagnostic system.

Xenarios et al. [64] studied the rates of agreement of fifteen drought-prone villages of South India on the climate variability effects. The authors used Fleiss' kappa statistic to demonstrate how men and women are affected differently by climate change.

In Vastrick et al. [65], five forensic document examiners analyzed 1025 handwritten specimen forms considering 32 handwritten numeral characteristics. The specimens were evaluated and resubmitted to evaluation to the same examiners after one month. The evaluations were made on a binary basis of presence/absence classifications according to the presence or absence of each handwritten characteristic. As a result, 25 of the 32 characteristics were unanimously agreed by the examiners, allowing discussions about the frequency of occurrence of each of them in the population.

Uccheddu et al. [66] correlated qualitative and quantitative methods for thoracic deformities evaluation using attribute agreement analysis based on Kendall's correlation coefficient. In this case, five physicians, experts in the researched field of surgery, were asked to blindly evaluate 51 patients according to a six-level scale. As a result, the authors demonstrated that computed tomographies and expert evaluations are convergent and positively correlated.

Marqués-Mateu et al. [67] applied a modified attribute agreement analysis to measure the color of 276 soil samples twice by four trained appraisers using graphical interpretations and compare them to the traditional computerized colorimeters. Exact and relaxed matching criteria were used in place of the Kappa and Kendall indexes. The results supported the advantages of using appraisers, rather than digital systems, among which are less raining requirements and faster data collection.

Although AAA is widely used in medical sciences, especially for disease diagnoses, and is reasonably applied in other fields of research for different types of assessments, the use of this technique in the areas of renewable energy, finance, and economics is still very scarce. Regarding the object of study, the literature generally addresses the analysis of investments in microgeneration focusing on the point of view of investor returns [68,33,18,35,70,71,72]. In turn, the application of the AAA proposed in this study aims to provide the assessment from multiple points of view, especially considering the perception of the impact of support schemes on investors and policy makers.

As formerly presented, AAA makes it possible to determine, quantitatively, the degree of inter-appraisers and intra-appraisers agreement. For this, an important assumption is to present different scenarios or cases to appraisers, so that statistical analyzes based on agreement indexes can be performed. In the studies available in the literature, these cases referred to physical injuries in horses [63], drought-prone villages [64], handwritten specimen forms [65], thoracic deformities [66], and soil samples [67].

To assess the economic feasibility and the social welfare of PV systems through AAA, different configurations need to be first evaluated by experts. This makes it possible to analyze the agreement between experts (through inter-expert evaluations). Then, as in previous research cited, these evaluations also need to be repeated, usually once after a given period of time. This allows investigating the degree of consistency of the experts (through intra-expert evaluations). Finally, AAA results are often compared to pre-existing standards (see, for example, the computed tomographies in Ref. [66], and the traditional computerized colorimeters in Ref. [67]). Analyses of investments in microgeneration typically uses the Net Present Value (NPV) as a standard [33,68]. In the next section, we present how the configurations of PV systems were planned and evaluated by the experts. Also, we detail the application of AAA and the calculation of NPV.

3. Material and methods

This section intends to present the method used to conduct this study. As mentioned previously, this paper proposes an AAA approach to verify if there is a consensus among experts, with different degrees and time of experience, on the specific characteristics of a PV system that makes it an economically feasible project for the prosumer, under fair financing conditions; for this, the sequence of steps shown in Fig. 2 was adopted.

3.1. Problem variables and scenario planning

Initially, the authors identified important factors to be considered for the configuration of the PV system, based on the peculiar characteristics of RES projects, such as the fact that the NPV is sensitive to the value of the tariff, the potential of energy production, and the amount spent on initial investments, in particular, expenses related to technology used for generation [19,33,73].

However, the value of the investment and the potential for the production of energy are the characteristics that can be controlled by the prosumer through a more rational decision making, but the same does not occur with the tariff, which is strictly determined by the regulatory agency. In this way, four measurable factors were defined that demonstrate a direct relationship with the behavior of the energy production and the form of financing:

- Installed power capacity;
- PV cell type;
- Debt ratio (percentage of third-party capital that will finance the investment in the system); and
- BNDES loan interest rate.

These factors were varied at two levels, as shown in Table 2. For factor A, we defined the maximum level (+1) as 75 kW, since it is the maximum power that characterizes a photovoltaic microgeneration system in Brazil. As 0 kW would mean that there is no photovoltaic system, for analysis purposes, it was considered that the smallest

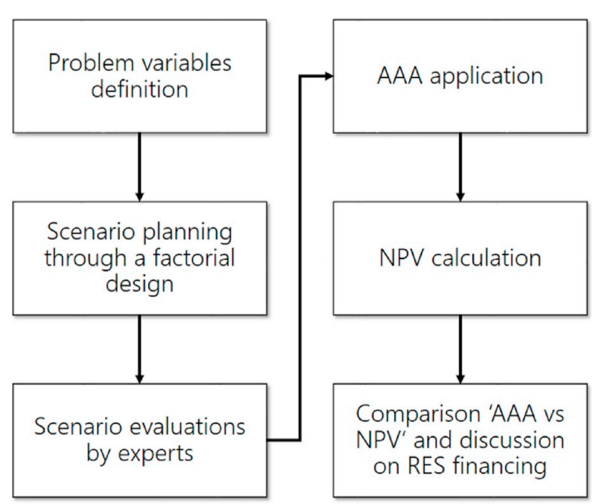

Fig. 2. Flowchart of the proposed method.

Table 2
Factors and levels for the proposed scenarios.

Factor	Level	
	Low (−1)	High (+1)
A. Installed power capacity	25 kW	75 kW
B. PV cell type	Crystalline (c-SC)	Multi-crystalline (m-Sc)
C. Debt ratio	26.67%	80.00%
D. BNDES loan interest rate	2.90%	4.90%

considerable power level for the system (−1) would be three times lower than the maximum power value (i.e., 25 kW). For factor B, we adopted the two most popular PV cells worldwide for photovoltaic power generation, crystalline, and multi-crystalline, as the levels −1 and +1, respectively. For factor C, we set the maximum level (+1) as 80% since it is the largest percentage that BNDES financed from total investments in photovoltaic microgeneration systems at the time the information was collected (November 2018). Since 0% would mean no need for funding (unlikely situation), a value three times lower than the maximum percentage value was used as the low level (−1) (i.e., 26.67%). Finally, for factor D, we adopted the lowest and highest possible interest rates (disregarding inflation) charged by the BNDES at the time the information was collected for the analysis (November 2018) (i.e., 2.90% (−1) and 4.90% (+1)).

From the combination of factors and levels, a full factorial design produced 16 scenarios with one replicate, as provided in Table 3. These scenarios were randomized and the first 16 were sent to six experts in PV systems for the first evaluation. Around one month later, the remaining scenarios were sent to the same experts for the second evaluation, requesting that they were evaluated independently of the previous consultation. The experts were required to evaluate the scenarios by using a 0–5 scale for two response variables: economic feasibility and maximization of social welfare. The descriptions of the response variables and the scale points are shown below:

Economic feasibility: refers to the potential of the PV system to provide energy savings and financial return to the prosumer. *Note: Assigning 0 means that the system, as proposed, is economically unfeasible (ie, it does not generate any energy savings). Assigning 5 means that the system, as proposed, is economically feasible (ie, generates a high energy saving).*

Maximization of social welfare: refers to the financing conditions to which the development bank lends the money for a project in a given scenario, in relation to the other scenarios presented to the experts. In this case, the bank must lend part of its budget to the project to become feasible, but not in conditions that provide extraordinary returns to the investor. *Note: Assigning 0 means that the financing condition privileges the investor too much and is not socially beneficial (ie there are other alternatives that should not be abdicated). Assigning 5 means that the financing condition is fair and socially beneficial (ie, there are other alternatives that should be abdicated).*

The scenarios designed in Table 3 configure systems that can be implemented with crystalline (c-SC) or multicrystalline (m-SC) PV cells, whose characteristics are described in Table 4, according to Ref. [74]. The estimated degradation factor for each type of PV cell was adopted from Honrubia-Escribano [75].

3.2. Mathematical modeling for the PV module

With regard to the production of electricity from PV power, the basic principle is to obtain an electric current when solar radiation hits the PV cells [76]. Both voltage and current electricity are radiation-dependent (Shukla et al., 2014); when radiation occurs, electrons are expelled from the semiconductor material present in PV cells and, having an electrical circuit connected, an electrical current is generated.

The production of PV electricity is mainly associated with both the local irradiation level and the losses that occur when the ambient temperature goes beyond 25 °C and for technical reasons such as shading, dirt, and dissipations that revolve around 20% of the total production [77]. In Eq (12). the mathematical model for estimating PV electricity is presented [78]:

$$E_{PV} = 0.8\eta IA(1 - \sigma_T T_+) \tag{12}$$

where: E_{PV} = PV potential energy (kWh); η = efficiency (%); I = local irradiation (kWh/m^2); A = area (m^2); σ_T = temperature loss coefficient; T_+ = temperature above 25 °C (when temperature is minor or equal 25 °C this value is zero).

Table 4
Characteristics of photovoltaic cells used.

Characteristics	c-Sc	m-Sc
PV cell power (W)	280	200
Efficiency (%)	19.8	16.2
Area (m^2)	1.6236	1.2969
Degradation rate by year (%)	0.90	0.70
Loss by temperature (%)	0.42	0.42
Number of cells required for 25 kW	90	125
Number of cells required for 75 kW	268	375

Table 3
Factorial design for the proposed scenarios.

First Evaluation						Second Evaluation					
Scenario		Factor				Scenario		Factor			
Std	Run	A	B	C	D	Std	Run	A	B	C	D
3	1	25	m-Sc	26.67	2.90	8	17	75	m-Sc	80.00	2.90
27	2	25	m-Sc	26.67	4.90	16	18	75	m-Sc	80.00	4.90
6	3	75	c-Sc	80.00	2.90	12	19	75	m-Sc	26.67	4.90
4	4	75	m-Sc	26.67	2.90	26	20	75	c-Sc	26.67	4.90
1	5	25	c-Sc	26.67	2.90	32	21	75	m-Sc	80.00	4.90
29	6	25	c-Sc	80.00	4.90	17	22	25	c-Sc	26.67	2.90
23	7	25	m-Sc	80.00	2.90	18	23	75	c-Sc	26.67	2.90
13	8	25	c-Sc	80.00	4.90	2	24	75	c-Sc	26.67	2.90
11	9	25	m-Sc	26.67	4.90	15	25	25	m-Sc	80.00	4.90
14	10	75	c-Sc	80.00	4.90	20	26	75	m-Sc	26.67	2.90
9	11	25	c-Sc	26.67	4.90	10	27	75	c-Sc	26.67	4.90
19	12	25	m-Sc	26.67	2.90	5	28	25	c-Sc	80.00	2.90
24	13	75	m-Sc	80.00	2.90	31	29	25	m-Sc	80.00	4.90
22	14	75	c-Sc	80.00	2.90	7	30	25	m-Sc	80.00	2.90
28	15	75	m-Sc	26.67	4.90	30	31	75	c-Sc	80.00	4.90
25	16	25	c-Sc	26.67	4.90	21	32	25	c-Sc	80.00	2.90

3.3. Studied object, experts, and attribute agreement analysis

In order to carry out the evaluations, it was considered a PV microgeneration system to be installed in the district of Trancoso, located on the southern coast of the state of Bahia (Brazil). The region's beaches attract many tourists throughout the year and for this reason, many resorts are located in This context opens the opportunity for installation of generation systems that provide energy savings to consumers.

In this sense, PV microgeneration appears with a good energetic alternative due to the solar potential of the region. Trancoso presents good levels of radiation throughout the year, especially in the summer months in the southern hemisphere. Addition, the temperature throughout the year is close to 25 °C, which favors the use of PV microgeneration. Fig. 3 shows the solar radiation and temperature in Trancoso.

The selected experts have experiences of 4–12 years, 3 belong to private organizations and 3 belong to public organizations. Among experts are economists (2) and electrical (3), industrial (1), and mechanical (1) engineers with Master of Science (MSc) or Doctor of Philosophy (Ph.D.) degree. The sample attributes of experts are shown in Table 5.

Then, the results of these consultations were submitted to an AAA, based on a factorial design with 16 subjects (distinct scenarios) and 6 appraisers (distinct experts). AAA was performed using Kendall's W and Fleiss' Kappa. Kendall's W indicates the degree of association between the experts when evaluating the same scenarios. Kendall's W also indicates the degree of association within each expert. Fleiss' Kappa indicates the degree of agreement of each expert when evaluating all scenarios with a 6-point scale. Higher indexes indicate the scenarios and assessments of greater agreement.

3.4. Financial returns and Net Present Value

In order to compare the experts' evaluation with the possible financial returns of the project, this study also calculates the NPV for each scenario. Among the decision criteria for investment analysis, NPV is the most recommended in the literature related to RES projects [33,79]. The NPV is based on the calculation of the present value of the future cash flows, based on the difference of the cash inflows and outflows, discounted by a discount rate [80].

Johnson [81] explains that NPV is easy to understand, as well as convincing and practical even for those who do not have knowledge of investment analysis. The formula for calculating NPV is given by Eq. (13):

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+i)^t} \tag{13}$$

where: i is the discount rate; CF_t is the cash flow at a certain time; t is the time; n is the project lifespan.

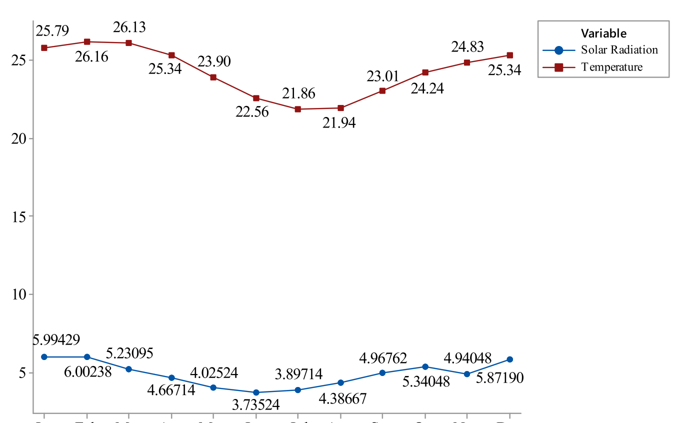

Fig. 3. Solar radiation and temperature in Trancoso.

Table 5
Sample attributes of experts.

N	Subject-matter expert	Public/private organization	Higher Degree	Time of experience with PV systems	Brief experience description
1	Economist	Public	M.Sc	5 years	Renewable energy policies, economic evaluation
2	Industrial Engineer	Public	M.Sc	4 years	Energy efficiency, statistical analysis
3	Electrical Engineer	Private	Ph.D.	12 years	Electrical power generation
4	Electrical Engineer	Private	M.Sc	5 years	Electrical power generation, solar cells, photovoltaic installations
5	Mechanical Engineer	Private	Ph.D.	4 years	Solar cells, photovoltaic installations
6	Economist/ Electrical Engineer	Public	Ph.D.	10 years	Renewable energy policies, economic evaluation

A negative NPV indicates that the investment is not attractive financially and should be rejected, in turn, a positive NPV signal that the investment is feasible and should be implemented [82]. In the case of a zero NPV, the investor fully recovers the amount invested, from an appropriate discount rate [69].

For the calculation of the discount rate, the cost of equity capital is estimated by the Capital Asset Pricing Model (CAPM), originally presented by Sharpe [83] added to the country risk, similar to that used by Refs. [78,79,84]. In Eq. (14), the calculation of the cost of equity capital is presented:

$$k_e = r_f + \beta \times (r_m - r_f) + r_b \tag{14}$$

where: r_f is the risk-free rate, β is the project risk regarding the market, r_m is the expected market return, and r_b is the Brazil risk premium.

Based on Rocha et al. [33], in the present study, β was calculated from an unleveraged β value (β $_{unleveraged}$) of the renewable energy sector. In Eq. (15) the formula for calculating β is described by the values of equity (E) and debt (D), which may be 26.67% or 80%, depending on each scenario analyzed.

$$\beta = \beta_{unleveraged}\left(1 + {}^{D}/_{E}\right) \tag{15}$$

4. Results and discussion

With the application of the proposed method, the agreement indexes Fleiss' Kappa and Kendall's W were evaluated by using Eqs. (5)–(10). Analyses of the expert evaluation profile and the response variables were then performed, based on the scenarios obtained.

4.1. Expert agreement and response variables comparison

In a first analysis, the expert agreement was measured according to the response variables. Tables 6 and 7 provide Kendall's W values between each of the experts for each of the response variables analyzed. As shown in Table 6, all the experts presented good agreement within (intra-expert) for economic feasibility, although experts 2, 3, 4 and 6

Table 6
Intra-expert and Inter-expert agreement measured by Kendall's W for economic feasibility[†].

		Expert					
		1	2	3	4	5	6
Expert	1	**0.8844**					
		0.0328					
	2	**0.8246**	**0.9009**				
		0.0000	0.0285				
	3	0.2886	0.3818	**0.9127**			
		0.3003	0.0861	0.0259			
	4	**0.7884**	**0.7891**	**0.4424**	**1.0000**		
		0.0000	0.0000	0.0327	0.0119		
	5	**0.4482**	**0.5100**	**0.6248**	**0.5715**	**0.8687**	
		0.0296	0.0099	0.0011	0.0031	0.0374	
	6	**0.5742**	**0.6424**	**0.5586**	**0.8159**	**0.6894**	**0.9849**
		0.0029	0.0007	0.0040	0.0000	0.0003	0.0137
						Overall	**0.3856**
							0.0000
Cell Contents:		Kendall's W P-value		[†] Significant terms are assigned in black.			

Table 7
Intra-expert and Inter-expert agreement measured by Kendall's W for maximization of social welfare[†].

		Expert					
		1	2	3	4	5	6
Expert	1	0.8257					
		0.0531					
	2	**0.6633**	**0.9780**				
		0.0005	0.0145				
	3	0.4032	0.5583	**0.8990**			
		0.0619	0.0040	0.0290			
	4	0.4128	**0.4890**	**0.4495**	*		
		0.0531	0.0145	0.0290			
	5	0.3023	**0.4377**	**0.7651**	**0.4276**	**0.8552**	
		0.2556	0.0354	0.0001	0.0418	0.0418	
	6	0.3315	0.3734	**0.6368**	**0.0484**	**0.7210**	**0.9686**
		0.1763	0.0977	0.0008	0.0158	0.0001	0.0158
						Overall	**0.2361**
							0.0002
Cell Contents:		Kendall's W P-value		[†] Significant terms are assigned in black. * When assessments across trials are identical, Kendall's coefficient cannot be computed			

presented the best performances (W > 0.90). On the other hand, concordances within greater than 0.90 for maximization of social welfare were only observed with experts 2 and 6, as shown in Table 7. This difference denotes that capturing the maximization of social welfare is more difficult than economic feasibility, even for experienced appraisers. This fact is also confirmed by the agreement index $W_{overall}$ (inter-expert), which is low for both response variables (W < 0.70), but higher for economic viability (W = 0.3885) than for maximization of well-being (W = 0.2361).

Despite the differences in the evaluation of the response variables, agreement indexes W_{within} (intra-expert) greater than 0.70 (main diagonal of the matrices of Tables 6 and 7) demonstrate the good consistency of the evaluations made by each expert. That is, none of them performed random evaluations, but they used a well-defined criterion. This validates the evaluation process, however, the low agreement indexes $W_{overall}$ indicate that the experts used different criteria to evaluate the presented scenarios.

Even experts with the same degrees did not use identical criteria. In one of the most consistent cases, for example, electrical engineers 4 and 6 showed good agreement on economic feasibility (W = 0.8159), but little agreement on maximizing social welfare (W = 0.0484).

4.2. Agreement by scale point

In an agreement analysis by scale point, it can be observed that there is greater agreement between experts for scenarios with assigns 4 and 5 than for scenarios with assigns 1, 2 and 3, both for economic feasibility (Kappa-4 = 0.7900 and Kappa-5 = 0.7993) and for maximization of social welfare (Kappa-4 = 0.7410 and Kappa-5 = 0.7568), as shown in Tables 8 and 9, respectively. This indicates that the more favorable scenarios are more likely to generate agreement between the experts, while more unfavorable scenarios lead to greater divergences.

In the evaluation process, none of the experts assigned 0 to any of the response variables in any of the scenarios, which shows that they all present some potential of economic feasibility and maximization of social welfare for installation in the region of Trancoso.

4.3. Expert biases and implications on public financing

Considering all four factors, section 4.1 showed that although economic feasibility has produced greater agreement than the maximization of social welfare, the $W_{overall}$ was very low (Table 6) for measuring a consolidated concept such as economic feasibility. The authors expected that, at least for this response variable, the agreement would be higher than the AAA good acceptability criteria provided by Fig. 2. Then, in order to investigate the causes of the low agreement for economic feasibility, an expanded AAA was performed. Table 10 provides this expanded analysis, making it possible to identify the technical and financial factors that drive the agreement between experts and produce some biases.

In the expanded AAA (Table 10), it can be observed that the experts have different agreement profiles for each factor. For the PV cell type (factor B), it is noted that there is no statistical evidence of the agreement between the experts (p-value = 0.6803). That is, each expert has a fairly distinct perception of the effect of PV cell type on the financial returns of investments in PV systems. For factors A and C, agreement on economic feasibility was poor ($W_{overall}$ <0.30), showing that the levels of these factors are also quite complex to distinguish. In the case of factor D, the agreement was higher, although not ideal (0.60 <$W_{overall}$ <0.70). With this, it can be inferred that the experts attribute similar relevance to the loan interest rate.

Fig. 4 complements the analysis of Table 10, by illustrating the main factorial plots for economic feasibility by an expert. In order to make comparisons between expert evaluation profiles for economic feasibility, the NPV was calculated.

For the NPV calculations, then, the cash flow was estimated according to the framework described in Fig. 5.

The value of the tariff charged by the utility that serves the region of Trancoso corresponds to $ 0.18,[1] the cost of O & M is equivalent to 4.9% per year of the value of the investment in the PV system [75] and the amortization period of the BNDES financing line, which is based on the constant amortization system, is 24 years. The estimated energy production for each scenario was calculated from PV potential energy, described in Eq. (12), discounting a loss of 25% due to shading, dust, and losses in the system [77,78]:

After calculating the cash flow over the 25-year life of the PV system, the NPV was calculated considering the discount rate estimated by Eqs. (14) and (15), according to the percentage of D and E of each scenario, and the values of the parameters described in Table 11.

From these data, the main factorial plot for NPV was generated, as shown in Fig. 6. From this figure, it is observed that factor A is the most determinant for NPV. Therefore, in theory, experts should have attributed greater relevance to factor A in evaluating economic feasibility. However, as shown in the analysis of Fig. 4, there is evidence that the

[1] Estimates assessed on 11/28/2018. Brazilian real to US Dollar conversion rate: 3.850.

Table 8
Intra-expert agreement measured by Fleiss' Kappa for economic feasibility[†]

		Expert						Mean Kappa
		1	2	3	4	5	6	
Scale point	0	*	*	*	*	*	*	*
	1	**0.4286**	−0.0667	**0.6322**	*	**0.7630**	*	0.4393
		0.0432	0.6051	0.0057		0.0011		
	2	**1.0000**	**0.4514**	**0.5897**	*	**0.4667**	**0.7630**	0.6542
		0.0000	0.0355	0.0092		0.0310	0.0011	
	3	0.2270	0.2270	**0.7091**	**1.0000**	0.2889	**0.8705**	0.5537
		0.1819	0.1819	0.0023	0.0000	0.1239	0.0002	
	4	**0.8171**	**0.3333**	**0.5897**	**1.0000**	**1.0000**	**1.0000**	0.7900
		0.0005	0.0912	0.0092	0.0000	0.0000	0.0000	
	5	**0.5897**	**0.5897**	**0.8171**	**1.0000**	*	**1.0000**	0.7993
		0.0092	0.0092	0.0005	0.0000		0.0000	
	Overall	**0.6030**	**0.3519**	**0.6776**	**1.0000**	**0.5509**	**0.9062**	0.6816
		0.0000	0.0043	0.0000	0.0000	0.0004	0.0000	
Cell Contents:	Kendall's W P-value							

[†] Significant terms are assigned in black. * When no or all responses across trials equal the value, kappa cannot be computed.

Table 9
Intra-expert agreement measured by Fleiss' Kappa for maximization of social welfare[†].

		Expert						Mean Kappa
		1	2	3	4	5	6	
Scale point	0	*	*	*	*	*	*	*
	1	**0.4286**	−0.0323	*	*	**0.6322**	*	0.3428
		0.0432	0.5513			0.0057		
	2	0.1795	**0.5897**	*	*	**0.3726**	*	0.3806
		0.2364	0.0092			0.0681		
	3	0.3074	**0.8454**	**0.7500**	*	**0.0857**	**0.7630**	0.5503
		0.1095	0.0004	0.0013		0.3659	0.0011	
	4	**0.5897**	**0.8704**	**0.6113**	*	**0.7630**	**0.8704**	0.7410
		0.0092	0.0002	0.0072		0.0011	0.0002	
	5	**0.7630**	**0.6322**	**0.6322**	*	*	**1.0000**	0.7568
		0.0011	0.0057	0.0057			0.0000	
	Overall	**0.4329**	**0.7363**	**0.6746**	*	**0.4110**	**0.8885**	0.6287
		0.0004	0.0000	0.0004		0.0050	0.0000	
CellContents:		Kendall's W P-value						

[†] Significant terms are assigned in black. * When no or all responses across trials equal the value, kappa cannot be computed.

experts did not have the understanding that factor A is the most determinant and, in addition, they have attributed a lot of relevance to factor D. That is, the experts perceive the loan interest rate as a factor that encourages investors to resort to subsidized financing lines because they believe that these lines will increase the profitability of the microgeneration system.

The NPV indicates the financial returns from investing in monetary values based on calculating the present value of discounted cash flows at a discount rate. Cash flow inflows and outflows are estimated based on market values and therefore subject to reasonably foreseeable variations. With AAA, however, the degree of agreement within and between experts for each scenario is examined, considering the evaluations of both the economic feasibility and social welfare. Although these aspects are expected to relate to NPV, especially the economic feasibility, the AAA reveals that the experts are more likely to think that the financing interest rate is the most influential variable on the returns on investments in photovoltaic systems which, of course. According to NPV's consolidated calculation, this is not true.

It is important to note that, in this paper, we are not questioning the effectiveness of NPV, but using it as a known metric for comparison with AAA, seeking to understand why experts are biased. This has been adopted because, although NPV is used in most work involving economic feasibility assessments, this is the first time AAA has been used for the evaluation of photovoltaic systems. Additionally, we use a comparative analysis of the methods to discuss the public financing policy adopted in Brazil. It is also important to highlight that the BNDES financing lines for PV microgeneration represent a recent strategy, created in 2018, to complement net metering in Brazil. Thus, as investments in PV microgeneration systems with the support of financing lines are still incipient, there is not enough data to carry out an ex-post evaluation of their results.

In fact, the results indicated in Fig. 6 allows important inferences about the lines subsidized by public banks. First, the results reveal that experts tend to have a project feasibility view distinct from what is observed by the NPV calculation. Therefore, it can be deduced that subjective evaluations do not prove to be an adequate alternative to guide the structure of the liberation of subsidized financing lines.

Another relevant aspect concerns the installed power capacity of the PV system as a determining factor for the NPV. It is known that the greater the capacity of the system, the greater the disbursement of the initial investment, highlighted in studies on renewable energy projects as a determinant factor for the sensitivity of NPV [19,33,73]. However, subsidized financing lines are developed to encourage new users of PV microgeneration to invest in the systems, which has been identified by a large number of experts consulted who considered the loan interest rate an important factor for the economic feasibility of the projects.

It is also known that the financing lines do not differentiate the interest charged according to the installed power capacity of the microgeneration system, which was revealed in the scenarios studied, considered as having loan interest rates independent of the system's powers. In other words, the subsidy of the development bank, represented by an interest rate below market value for PV microgeneration, is the same for the two systems with the highest capacity, in the power range that characterizes microgeneration systems in Brazil, such as those

Table 10
Intra-expert and Inter-expert agreement measured by Kendall's W for economic feasibility according to the factor of interest†.

E/E‡	Factor A						Factor B					
	1	2	3	4	5	6	1	2	3	4	5	6
1	**0.3750**						**0.5208**					
	0.0143						0.0039					
2	**0.4444**	**0.5208**					**0.4905**	**0.4602**				
	0.0002	0.0039					0.0001	0.0067				
3	0.0313	0.0909	0.0250				**0.2045**	**0.1800**	0.0250			
	0.3173	0.0881	0.5271				0.0105	0.0164	0.5271			
4	**0.1875**	**0.2604**	0.0125	*			**0.2604**	**0.2301**	0.0125	*		
	0.0143	0.0039	0.5271				0.0039	0.0067	0.5271			
5	**0.4136**	**0.4905**	0.0729	**0.2301**	**0.4602**		0.0250	0.0148	0.0278	**0.1406**	**0.2812**	
	0.0003	0.0001	0.1266	0.0067	0.0067		0.3711	0.4913	0.3458	0.0339	0.0339	
6	**0.3521**	**0.4301**	0.0729	**0.1701**	**0.4000**	**0.3403**	0.0052	0.0122	0.0278	**0.3750**	**0.5063**	**0.7500**
	0.0008	0.0002	0.1266	0.0196	0.0003	0.0196	0.6831	0.5316	0.3458	0.0005	0.0001	0.0005
					Overall	**0.1953**					Overall	0.0018
						0.0000						0.6803
E/E‡	Factor C						Factor D					
	1	2	3	4	5	6	1	2	3	4	5	6
1	**1.0000**						0.1607					
	0.0001						0.1088					
2	**0.8167**	**0.6429**					**0.3077**	**0.5208**				
	0.0000	0.0013					0.0017	0.0039				
3	0.0097	0.0012	**0.8125**				**0.4464**	**0.6923**	**0.8750**			
	0.5775	0.8474	0.0003				0.0002	0.0000	0.0002			
4	**1.0000**	**0.8167**	0.0097	**1.0000**			**0.5042**	**0.7545**	**0.9375**	**1.0000**		
	0.0000	0.0000	0.5775	0.0001			0.0001	0.0000	0.0000	0.0001		
5	**0.2552**	**0.1420**	**0.3348**	**0.2552**	0.0313		**0.2813**	**0.4905**	**0.6613**	**0.7334**	**0.4602**	
	0.0043	0.0330	0.0011	0.0043	0.4795		0.0027	0.0001	0.0000	0.0000	0.0067	
6	**0.7188**	**0.5372**	**0.3348**	**0.7188**	0.0521	**0.4375**	**0.4464**	**0.6923**	**0.6613**	**0.9375**	**0.6613**	**0.8750**
	0.0000	0.0000	0.0011	0.0000	0.1967	0.0082	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
					Overall	**0.1824**					Overall	**0.6123**
						0.0000						0.0000

Cell Contents: Kendall's W / P-value

† Significant terms are assigned in black. * When no or all responses across trials equal the value, kappa cannot be computed.‡ Expert/Expert

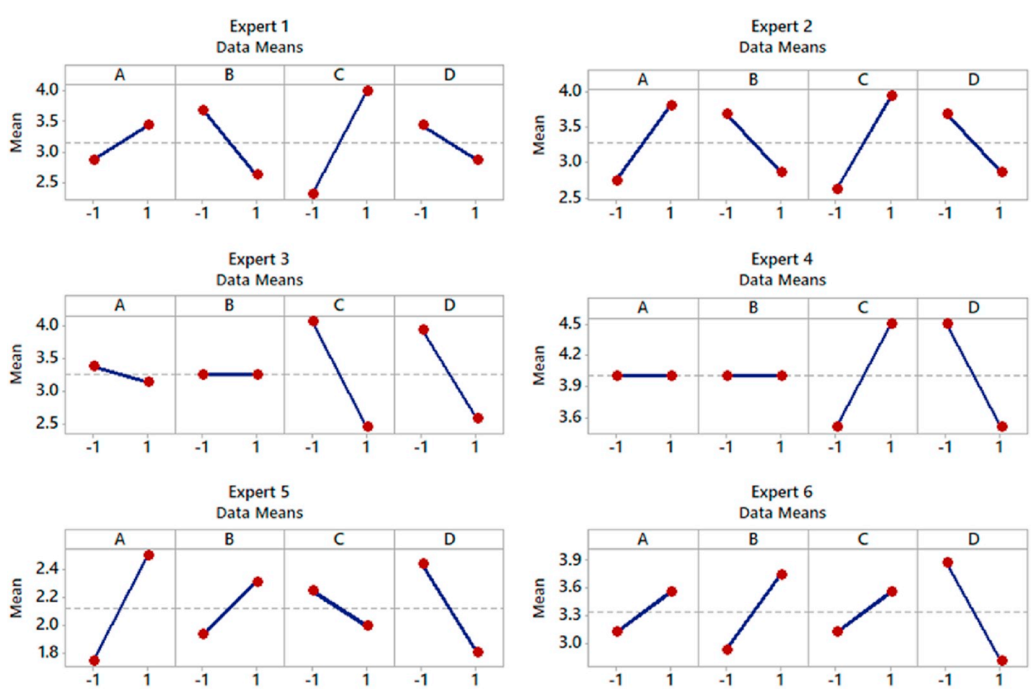

Fig. 4. Main factorial plots for economic feasibility by experts.

with 75 kW that are almost four times greater profitability than 25 kW, as for systems with lower capacity.

Thus, it is possible to infer that if the interest rate charged by the development bank was progressive, that is, increasing according to the installed power capacity of the system, the NPV profile (Fig. 6) might be closer to the economic feasibility evaluated by the experts, at least in relation to factors A and D. Under this condition, larger projects, with greater potential to be feasible, could feel less encouraged to use the

(+)Energy-saving credits
(-) O&M
(-) Investment
(+) Loan release
(-) Installments (interest + amortization)
(=) Cash Flow

Fig. 5. Valuation framework.

Table 11
Parameters for VPL evaluation.

Parameter	Value	Source
R_f	1.78%	[81]
R_m	9.345	[81]
r_b	2.62%	[81]
$\beta_{unleveraged}$	0.7	[34]
β	Calculated	Eq. (14)
Inflation rate (USA)	2.41%	[81]
Discount rate (ke)	Calculated	Eq. (13)

The NPV for each scenario is shown in Table 12.

subsidized financing line, making most of the budget of the line available for systems with less condition to be feasible without financing. In this way, the use of the public resource would be obeying the principle of equity, and, consequently, promoting greater social welfare.

This context helps to explain why there was not a factor with a greater agreement for the maximization of social welfare, as shown in Table 13. In this analysis, it can be observed that for both PV cell type (factor B) and loan interest rate (factor D), there is no statistical evidence of an agreement between the specialists (p-value> 0.05). For factors A and C, the agreement was also found to be low ($W_{overall}$ <0.33). This result shows that, since the financing is not progressive to the capacity of the system, neither the loan interest rate nor the power is determinant for this response variable, just as the PV cell type and the debt ratio are not either. Thus, the expert agreement profiles (0.00 <$W_{overall}$ <0.33) reveals that, in the current financing conditions, in fact, none of the factors makes it possible to maximize social welfare, since the criterion for subsidies is homogeneous.

In future scenarios, if there are changes in the financing policy of public banks for progressive loan interest rates, the analyses in Table 13 and in Fig. 7 may be used as a reference to compare the expert profiles regarding the four factors, especially the installed power capacity and the loan interest rate.

4.4. Further discussions on the proposed approach

It can be seen from the previous sections that the proposed approach based on AAA has met the objective of assessing the scenarios from the points of view of both the investor and public banks that subsidize PV microgeneration systems. This is because the proposed method allows us to evaluate the impact of subsidies and support schemes considering different attributes in expert assessment; furthermore, it is a tool to support decision making and regulatory policy evaluation for RES electricity.

In the present study, it was observed that the experts have difficulty in understanding the most appropriate system configuration to maximize social welfare. In addition, experts' perception of the impact of interest rates on system feasibility contrasts with NPV calculation. From previous analyses, a ranking of factors by attribute and expert was built. Thus, in Table 14, we can identify some additional aspects of expert assessments.

For the economic feasibility, none of the experts considered the PV cell type as the most important factor; which is actually verified via NPV. This shows that, although there are disagreements, experts tend to favor financial aspects. For the maximization of social welfare, Table 14 reveals that factor B is considered important or most important by experts 1, 2, and 6. These experts are likely to have considered environmental aspects and more technical features of the cells to infer that PV cell type is one of the most influential factors on the maximization of social welfare, so that other energy alternatives, such as wind power generation or other PV systems are more attractive in some scenarios.

Expert 3, in turn, considered factors C and D as Most Important (MI) and Important (I), respectively. Apparently, this expert did not identify differences between the maximization of social welfare and the economic feasibility, both being more linked to financial aspects. Expert 5 appropriately assessed factor A as MI for economic feasibility,

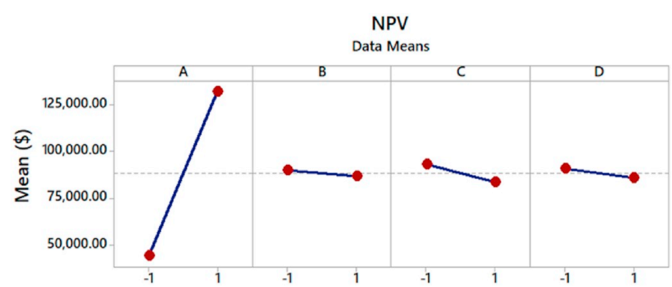

Fig. 6. Main factorial plot for NPV.

Table 12
Evaluated NPV for each scenario.

First Evaluation		Second Evaluation		Factor				Initial Investment[a]	NPV[a]
Std	Run	Std	Run	A	B	C	D		
1	5	17	22	25	c-Sc	26.67	2.90	$ 27,207.79	$ 48,392.66
2	24	18	23	75	c-Sc	26.67	2.90	$ 81,623.38	$ 143,303.39
3	1	19	12	25	m-Sc	26.67	2.90	$ 23,896.10	$ 46,336.33
4	4	20	26	75	m-Sc	26.67	2.90	$ 71,688.31	$ 139,008.98
5	28	21	32	25	c-Sc	80.00	2.90	$ 27,207.79	$ 44,845.21
6	3	22	14	75	c-Sc	80.00	2.90	$ 81,623.38	$ 133,043.09
7	30	23	7	25	m-Sc	80.00	2.90	$ 23,896.10	$ 42,304.03
8	17	24	13	75	m-Sc	80.00	2.90	$ 71,688.31	$ 126,912.10
9	11	25	16	25	c-Sc	26.67	4.90	$ 27,207.79	$ 46,962.10
10	27	26	20	75	c-Sc	26.67	4.90	$ 81,623.38	$ 139,011.69
11	9	27	2	25	m-Sc	26.67	4.90	$ 23,896.10	$ 45,079.89
12	19	28	15	75	m-Sc	26.67	4.90	$ 71,688.31	$ 135,239.66
13	8	29	6	25	c-Sc	80.00	4.90	$ 27,207.79	$ 41,376.65
14	10	30	31	75	c-Sc	80.00	4.90	$ 81,623.38	$ 122,637.41
15	25	31	29	25	m-Sc	80.00	4.90	$ 23,896.10	$ 39,257.66
16	18	32	21	75	m-Sc	80.00	4.90	$ 71,688.31	$ 117,772.98

[a] Estimates assessed on 11/28/2018. Brazilian real to US Dollar conversion rate: 3.850.

Table 13
Intra-expert and Inter-expert agreement measured by Kendall's W for maximization of social welfare according to the factor of interest[†].

E/E[‡]	Factor A						Factor B					
	1	2	3	4	5	6	1	2	3	4	5	6
1	0.0511						0.2356					
	0.3657						0.0522					
2	**0.2514**	**0.6250**					**0.5104**	**0.8750**				
	0.0046	0.0016					0.0001	0.0002				
3	**0.1420**	**0.4301**	**0.2784**				0.1111	**0.3701**	0.0125			
	0.0330	0.0002	0.0348				0.0593	0.0006	0.6547			
4	0.0257	**0.3125**	**0.1392**	*			0.1178	**0.4375**	0.0063	*		
	0.3657	0.0016	0.0348				0.0522	0.0002	0.6547			
5	**0.2045**	**0.5372**	**0.3636**	**0.2301**	**0.4602**		0.0015	0.0909	0.0601	**0.1406**	**0.2813**	
	0.0105	0.0000	0.0006	0.0067	0.0067		0.8273	0.0881	0.1655	0.0339	0.0339	
6	**0.3333**	**0.7188**	**0.5208**	**0.4063**	**0.6302**	**0.8125**	0.0432	0.0011	**0.2500**	**0.4063**	**0.5372**	**0.8125**
	0.0011	0.0000	0.0000	0.0003	0.0000	0.0003	0.2393	0.8474	0.0047	0.0003	0.0000	0.0003
					Overall	**0.3281**					Overall	0.0018
						0.0000						0.6803

E/E[‡]	Factor C						Factor D					
	1	2	3	4	5	6	1	2	3	4	5	6
1	0.1202						**0.5817**					
	0.1655						0.0023					
2	**0.1731**	0.2356					**0.2784**	0.0625				
	0.0186	0.0522					0.0028	0.3173				
3	**0.2515**	**0.3348**	**0.5000**				0.0057	0.0625	**0.5625**			
	0.0046	0.0011	0.0047				0.6698	0.1573	0.0027			
4	0.0601	0.1178	**0.2500**	*			**0.2909**	0.0313	**0.2813**	*		
	0.1655	0.0522	0.0047				0.0023	0.3173	0.0027			
5	**0.3613**	**0.4513**	**0.6250**	**0.3750**	**0.7500**		0.0227	0.0278	**0.4444**	**0.1701**	**0.3403**	
	0.0007	0.0001	0.0000	0.0005	0.0005		0.3938	0.3458	0.0002	0.0196	0.0196	
6	0.0357	0.0804	**0.1701**	0.0313	**0.2907**	0.0625	**0.1250**	0.0000	**0.3750**	0.0938	**0.2604**	0.1875
	0.2850	0.1088	0.0196	0.3173	0.0023	0.3173	0.0455	1.0000	0.0005	0.0833	0.0039	0.0833
					Overall	**0.2130**					Overall	0.0061
						0.0000						0.4458

Cell Contents: Kendall's W / P-value

† Significant terms are assigned in black. * When no or all responses across trials equal the value, kappa cannot be computed.[‡] Expert/Expert

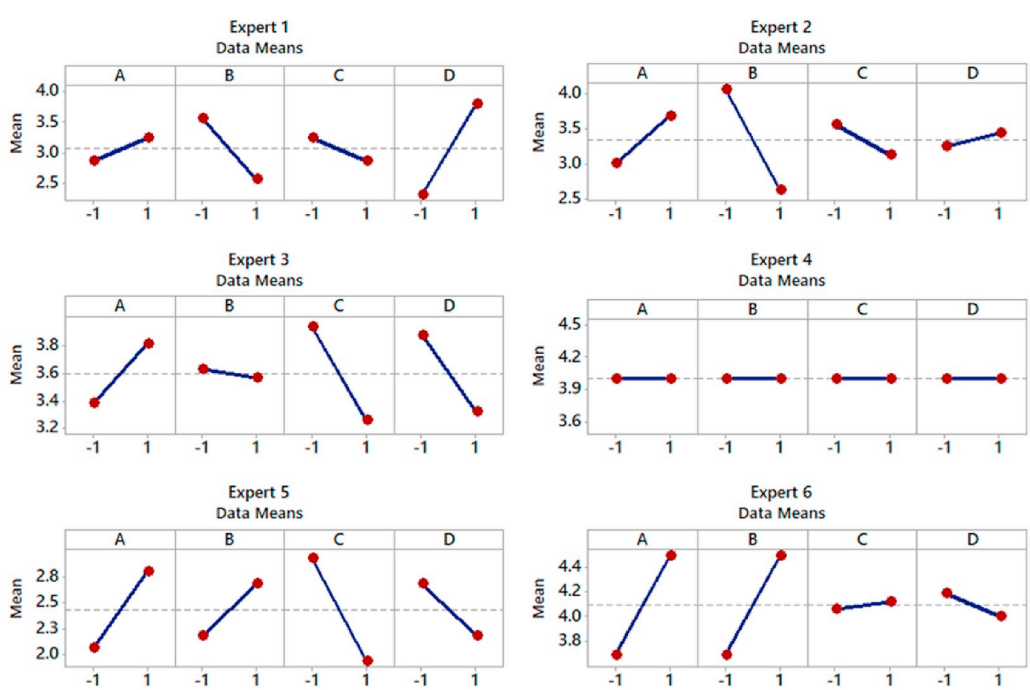

Fig. 7. Main factorial plots for maximization of social welfare by experts.

corresponding to NPV, and judged factor C (debt ratio) as MI for the maximization of social welfare. It is likely that this expert is considering the allocation of public resources for renewable energy projects as the most relevant aspect, followed by the technical aspect of generation (since factor A was rated I).

The multiple points of view of experts with different degrees of experience, as well as the consideration of multiple attributes in the assessment, highlight the complexity for policy makers to reach an

Table 14
Ranking of factors by attribute and expert based on AAA.[a]

Expert/Factor	Economic feasibility				Maximization of social welfare			
	A	B	C	D	A	B	C	D
1	Q	I	MI	NI	Q	I	NI	MI
2	I	Q	MI	NI	NI	MI	Q	NI
3	Q	NI	MI	I	Q	NI	MI	I
4	–	–	I	MI	–	–	–	–
5	MI	Q	NI	I	I	NI	MI	Q
6	Q	I	NI	MI	MI	I	NI	Q
NPV	MI	NI	I	Q	–	–	–	–

[a] MI: Most Important; I: Important; Q: Qualifier; NI: Not Important.

optimal decision in the face of a trade-off. This complexity is due to the fact that in most cases the objectives analyzed by different points of view are conflicting.

Therefore, it may be interesting to consider further studies proposed for the improvement of these financing lines, based on quantitative cost-benefit and multi-objective optimization methods, which may reconcile the objectives that are of interest to stakeholders in the PV micro-generation market. In addition, future work will conduct interviews with experts to better understand the aspects that led to the scenario assessments discussed in this paper.

5. Conclusions

This paper presented a new proposal for the evaluation of RES projects, taking into account both the perspective of the prosumer, which invests in microgeneration, and that of national development banks, which support RES micro-generation projects from subsidized financing lines. In view of the results, the goal of analyzing these different points of view was accomplished, allowing us to discuss the Brazilian public financing policy. For this, we used an innovative approach based on AAA and a traditional economic evaluation based on NPV.

Initially, six experts in PV systems were consulted about 16 PV microgeneration scenarios in Trancoso, a district in the northeast of Brazil. The obtained data were then submitted to the AAA, based on the indexes Fleiss' Kappa and Kendall's W. From a first examination, it was noticed that there is a significant disagreement between the experts, revealing the complexity of evaluating PV microgeneration projects.

The analyses showed that, despite using consistent standards in individual evaluations, the experts used distinct criteria to evaluate the scenarios. Even experts with the same academic background used discordant criteria, at least for the maximization of social welfare. In future studies along these lines, comprehensive questionnaires and interviews are recommended to express the experts' viewpoints in a more detailed way.

From the current study, however, it is clear that the interpretation of which photovoltaic system configuration would be the most appropriate in promoting social welfare is subjective and controversial. Therefore, for future studies aimed at guiding policy makers on improving support schemes for RES, multiobjective optimization methods are recommended as part of systems planning, providing thus objective responses.

The results also indicated that scenarios with greater economic and/or social potentials, assigned with 4 or 5, presented a greater agreement between the experts, while less favorable scenarios, assigned with 1–3, showed less agreement. This shows that scenarios with great potential are easier to identify, generating greater agreement, while scenarios of lower potential place the experts in doubt, generating less agreement between them.

This study showed that the economic feasibility profile is more easily captured by expert evaluations than the maximization of social welfare, although the experts have shown a bias in relation to the impact of the loan interest rate on the economic feasibility that, based on NPV calculations are more influenced by system capacity.

A comparison of AAA and NPV results revealed that experts had a different perception of the sensitivity of NPV for each variable. Thus, it can be inferred that the impact of the interest rate charged on financing has been overestimated by the experts, which may be an indication that prosumers may also be induced to mistakenly reject an investment from the same perspective.

In fact, the profiles of NPV and the maximization of social welfare reflected the RES incentive policy currently used in Brazil, where the loan interest rate is independent of the capacity of the system, making the interest rate effect small in NPV and making all four factors to be considered of little relevance to the maximization of social welfare.

As this is the first time that AAA is used for RES projects evaluation, the profiles of each response variable can serve as a reference in future contexts if the current financing policies are reformulated, considering progressive interest rates in relation to the capacity of the system.

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CRediT authorship contribution statement

Lucas Guedes de Oliveira: Conceptualization, Methodology, Formal analysis, Investigation, Software, Writing - original draft, Writing - review & editing, Visualization. **Giancarlo Aquila:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Visualization. **Pedro Paulo Balestrassi:** Conceptualization, Resources, Funding acquisition, Supervision, Project administration. **Anderson Paulo de Paiva:** Methodology, Formal analysis, Resources, Funding acquisition, Supervision. **Anderson Rodrigo de Queiroz:** Resources, Data curation, Supervision. **Edson de Oliveira Pamplona:** Resources, Data curation, Supervision. **Ulisses Pessin Camatta:** Resources, Data curation.

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References

[1] Shezan SKA, Julai S, Kibria MA, Saidur R, Chong WT, Akikur RK. Performance analysis of an off-grid wind-PV (photovoltaic)-diesel-battery hybrid energy system feasible for remote areas. J Clean Prod 2016;125:121–32.
[2] Wesseh Jr PK, Lin B. A real options valuation of Chinese wind energy technologies for power generation: do benefits from the feed-in tariffs outweigh costs? J Clean Prod 2016;112:1591–9.
[3] Faggiani R, Barquín J, Hakvoort R. Risk-based assessment of the cost efficiency and the effectivity of renewable energy support schemes: certificate markets versus feed-in tariffs. Energy Pol 2013;55:648–61.
[4] Wong S, Bhattacharya K, Fuller JD. Long term effects of feed-in tariffs and carbon taxes on distribution systems. IEEE Trans Power Syst 2010;25(3):1241–53.
[5] Eleftheriadis IM, Anagnostopoulou EG. Identifying barriers in the diffusion of renewable energy sources. Energy Pol 2015;80:153–64.
[6] Ayoub N, Yuji N. Governmental intervention approaches to promote renewable energies – special emphasis on Japanese feed-in tariff. Energy Pol 2012;43: 191–201.
[7] Abdomouleh Z, Alammari RAM, Gastli A. Review of policies encouraging energy integration & best practices. Renew Sustain Energy Rev 2015;45:246–62.
[8] Aquila G, Pamplona EO, Queiroz AR, Rotela P, Fonseca MN. An overview of incentive policies for the expansion of renewable energy generation in electricity power systems and the Brazilian experience. Renew Sustain Energy Rev 2017;70: 1090–8.
[9] Couture TD, Gagnon Y. An analysis of feed-in tariff remunerations models: implications for renewable energy investment. Energy Pol 2010;38. 955-065.

[10] Holm D, Arch D. Renewable energy for the developing world. International Solar Energy Society (ISES). White paper, http://whitepaper.ises.org. [Accessed 15 November 2018].
[11] Mir-Artigues P, Del Río P. Combining tariffs, investment subsidies and soft loans in an electricity deployment support. Energy Pol 2014;69:430–42.
[12] Pereira MG, Camacho CF, Freitas MAV, Silva NF. The renewable energy in Brazil: current status and potential. Renew Sustain Energy Rev 2012;16:3786–802.
[13] Ramírez FJ, Honrubia-Escribano A, Gómez-Lázaro E, Pham DT. Combining feed-in tariffs and net-metering schemes to balance development in adoption of photovoltaic energy: comparative economic assessment and policy implications for European countries. Energy Pol 2017;102:440–52.
[14] Darghouth NR, Wiser RH, Barbose G, Mills AD. Net metering and Market feedback loops: exploring the impact of retail rate design on distributed PV deployment. Appl Energy 2016;162:713–22.
[15] Bayod-Rújula AA. Future development of the electricity systems with distributed generation. Energy 2009;37:377–83.
[16] Yamamoto Y. Pricing electricity from residential photovoltaic systems: a comparison of feed-in tariffs, net metering and net purchase and sale. Sol Energy 2012;86:2678–85.
[17] Eid C, Guillen JR, Marín PF, Hakvoort R. The economic effect of electricity net-metering with solar PV: consequences for network cost recovery, cross subsidies and policy objectives. Energy Pol 2014;75:244–54.
[18] Watts D, Valdes MF, Jara D, Watson A. Potential residential PV development in Chile: the effect of Net Metering and Net Billing schemes for grid connected PV systems. Renew Sustain Energy Rev 2015;41:1037–51.
[19] Boomsa TK, Meade N, Fleten SE. Renewable energy investments under different support schemes: a real option approach. Eur J Oper Res 2012;220:225–37.
[20] Katsaprakakis DA, Christakis DG. The exploitation of electricity production projects from Renewable Energy Sources for the social and economic development of remote communities. The case of Greece: an example to avoid. Renew Sustain Energy Rev 2016;54:341–9.
[21] Lee M, Hong T, Koo C. An economic impact analysis of state solar incentives for improving financial performance of residential solar photovoltaic systems in the United States. Renew Sustain Energy Rev 2016;58:590–607.
[22] Shezan S, Al-Mamoon A, Ping H. Performance investigation of an advanced hybrid renewable energy system in Indonesia. Environ Prog Sustain Energy 2018;37(4):1424–32.
[23] Shezan S, Das N, Mahmudul H. Techno-economic analysis of a smart-grid hybrid renewable energy system for brisbane of Australia. Energy Procedia 2017;110 (2017):340–5.
[24] Shezan S, Ping H. Techno-economic and feasibility analysis of a hybrid PV-Wind-Biomass-Diesel energy system for sustainable development at offshore areas in Bangladesh. Current Alternative Energy 2017;1(1):20–32.
[25] Shezan SA, Das N. Optimized hybrid wind-diesel energy system with feasibility analysis. Technology and Economics of Smart Grids and Sustainable Energy 2017;2 (1):9.
[26] Faria Jr H, Trigoso FBM, Cavalcanti JAM. Review of distributed generation with photovoltaic grid connected systems in Brazil: challenges and prospects. Renew Sustain Energy Rev 2017;75:469–75.
[27] ANEEL – Brazilian Electricity Regulatory Agency. Normative resolution nº 687, of November, 24; 2015.
[28] Ferreira A, Kuhn SS, Fagnani KC, De Souza TA, Tonezer C, Santos GR, Coimbra-Araujo CH. Economic overview of the use and production of photovoltaic solar energy in Brazil. Renew Sustain Energy Rev 2018;81:181–91.
[29] Pinto JTM, Amaral KJ, Janissek PR. Deployment of photovoltaics in Brazil: scenarios, perspectives and policies for low-income housing. Sol Energy 2016;133:73–84.
[30] CONFAZ – Brazilian National Finance Policy Council. Convênio ICMS 16, of april 22. https://www.confaz.fazenda.gov.br/legislacao/convenios/2015/CV016_15. [Accessed 15 November 2018].
[31] Souza LEV, Cavalcante AMG. Towards a sociology of energy and globalization: interconnectedness, capital, and knowledge in the Brazilian solar photovoltaic industry. Energy Res Soc Sci 2016;21:145–54.
[32] Holdermann C, Kissel J, Beigel J. Distributed photovoltaic generation in Brazil: an economic viability analysis of small-scale photovoltaic systems in the residential and commercial sectors. Energy Pol 2014;67:612–7.
[33] Rocha LC, Aquila G, Pamplona E, Paiva AP, Chieregatti BG, Lima JS. Photovoltaic electricity production in Brazil: a stochastic economic viability analysis for small systems in the face of net metering and tax incentives. J Clean Prod 2017;168:1448–62.
[34] NREL – National Renewable Energy Laboratory. SWERA project. http://en.openei.org/wiki/Brazil. [Accessed 15 November 2018].
[35] Mabee WE, Mannion J, Carpenter T. Comparing the feed-in tariff incentive for renewable electricity in Ontario and Germany. Energy Pol 2012;40:480–9.
[36] Jacobs D, Marzolf N, Paredes JR, Rickerson W, Becker-Birck C, Solano-Peralta M. Analysis of renewable energy incentives in the Latin America and Caribbean region: the feed in tariff case. Energy Pol 2013;60:601–10.
[37] Box GEP, Draper NR. Response surfaces, mixtures, and ridge analyses. 2nd ed. Hoboken: John Wiley & Sons; 2007.
[38] Khuri AI, Cornell JA. Response surface: design and analyses. 2nd ed. New York: Marcel Dekker Inc.; 1996.
[39] Montgomery DC. Designs and analysis of experiments. 9th ed. New York: John Wiley & Sons; 2017.
[40] Myers RH, Montgomery DC. Response Surface Methodology: process and product optimization using designed experiments. 3rd ed. New York: John Wiley & Sons; 2009.
[41] Oliveira LG, Paiva AP, Balestrassi PP, Ferreira JR, Costa SC, Campos PHS. Response surface methodology for advanced manufacturing technology optimization: theoretical fundamentals, practical guidelines, and survey literature review. Int J Adv Manuf Technol 2019;104:1785–837.
[42] Oliveira LG, Paiva AP, Campos PHS, Paiva EP, Balestrassi PP. Prediction capability of Pareto optimal solutions: a multi-criteria optimization strategy based on model capability ratios. Precis Eng 2019;59:185–210.
[43] Monticeli AP, Balestrassi PP, Souza ACZ, Leme RC, Paiva AP. Mixture design of experiments on portfolio optimisation of power generation. IET Gener, Transm Distrib 2017;11(2):322–9.
[44] Bendato I, Cassettari L, Mosca M, Mosca R. A design of experiments/response surface methodology approach to study the economic sustainability of a 1 MWe photovoltaic plant. Renew Sustain Energy Rev 2015;51:1664–79.
[45] Ghiaus C, Jabbour N. Optimization of multifunction multi-source solar systems by design of experiments. Sol Energy 2012;86(1):593–607.
[46] Montgomery DC. Introduction to statistical quality control. 7th ed. New York: John Wiley & Sons; 2012.
[47] AIAG – Automotive Industry Action Group. Measurement systems analysis: reference manual. 4th ed. Detroit: AIAG; 2010.
[48] Pereira RBD, Peruchi RS, Paiva AP, Costa SC, Ferreira JR. Combining Scott-Knott and GR&R methods to identify special causes of variation. Measurement 2016;82:135–44.
[49] Montgomery DC, Runger GC. Gauge capability and designed experiments. Part I: basic methods. Qual Eng 1993;6(1):115–35.
[50] Wheeler DJ. EMP III - evaluating the measurement process: using imperfect data. Knoxville: SPC PRESS (Statistical Process Control); 2006.
[51] Peruchi RS, Balestrassi PP, Paiva AP, Ferreira JR, Carmelossi MS. A new multivariate gage R&R method for correlated characteristics. Int J Prod Econ 2013;144(1):301–15.
[52] Sagnak M, Kazancoglu Y. Integration of green lean approach with six sigma: an application for flue gas emissions. J Clean Prod 2016;127:112–8.
[53] Sansom C, Fernández-García A, King P, Sutter F, Segura AG. Reflect on meter comparison for assessment of back-silvered glass solar mirrors. Sol Energy 2017;155:496–505.
[54] Stamatis DH. Quality assurance: applying methodologies for launching new products, Services, and customer satisfaction. Boca Raton: CRC Press; 2015.
[55] Fleiss J. Measuring nominal scale agreement among many raters. Psychol Bull 1971;76(5):378–82.
[56] Fleiss J. Statistical methods for rates and proportions. New York: John Wiley & Sons; 1981.
[57] Gisev N, Bell JS, Chen TF. Interrater agreement and interrater reliability: key concepts, approaches, and applications. Res Soc Adm Pharm 2013;9:330–8.
[58] Lewis GH, Johnson RG. Kendall's coefficient of concordance for sociometric rankings with self excluded. Sociometry 1971;34(4):496–503.
[59] Legendre P. Species associations: the Kendall coefficient of concordance revisited. J Agric Biol Environ Stat 2005;10(2):226–45.
[60] Siegel S, Castellan NJ. Nonparametric statistics for the behavioral sciences. 2nd ed. New York: McGraw-Hill; 1988.
[61] Agresti A. Analysis of ordinal categorical data. 2nd ed. Hoboken: John Wiley & Sons; 2010.
[62] Hinkle DE, Wiersma W, Jurs SG. Applied statistics for the behavioral sciences. 5ed. Boston: Houghton Mifflin; 2003.
[63] Mejdell CM, Jørgensen GH, Rehn T, Fremstad K, Keeling L, Bøe KE. Reliability of an injury scoring system for horses. Acta Vet Scand 2010;52(1):68–74.
[64] Xenarios S, Kakumanu KR, Nagothu US, Kotapati GR. Gender differentiated impacts from weather extremes: insight from rural communities in South India. Environmental Development 2017;24:156–69.
[65] Vastrick BSTW, Schuetzner BAE, Osborn K. Measuring the frequency occurrence of handwritten numeral characteristics. Forensic Sci 2017;63(4):1215–20.
[66] Uccheddu F, Ghionzoli M, Volpe Y, Servi M, Furferi R, Governi L, Facchini F, Piccolo RL, McGreevy KS, Martin A, Carfagni M, Messineo A. A novel objective approach to the external measurement of pectus excavatum severity by means of an optical device. Ann Thorac Surg 2018;106:221–7.
[67] Marqués-Mateu A, Moreno-Ramón H, Balasch S, Báñez-Asensio S. Quantifying the uncertainty of soil colour measurements with Munsell charts using a modified attribute agreement analysis. Catena 2018;171:44–53.
[68] Rocha LC, Aquila G, Rotela Junior P, Paiva AP, Pamplona EO, Balestrassi PP. A stochastic economic viability analysis of residential wind power generation in Brazil. Renew Sustain Energy Rev 2018;90:412–9.
[69] Arnold U, Yildiz O. Economic risk analysis of decentralized renewable energy infrastructures-A Monte Carlo Simulation approach. Renew Energy 2015;77:227–39.
[70] Tudisca S, Di Trapani AM, Sgroi F, Testa R, Squatrito R. Economic analysis of PV systems on buildings in Sicilian farms. Renew Sustain Energy Rev 2013;28:691–701.
[71] Walters R, Walsh PR. Examining the financial performance of micro-generation wind projects and the subsidy effects of feed-in tariffs for urban locations in the United Kingdom. Energy Pol 2011;39:5167–81.
[72] Talavera DL, Nofuentes G, Aguilera J. The internal rate of return of photovoltaic grid-connected systems: a comprehensive sensitivity analysis. Renew Energy 2010;35:101–11.
[73] Aquila G, Rotela Jr P, Pamplona EO, Queiroz AR. Wind power feasibility analysis under uncertainty in the Brazilian electricity market. Energy Econ 2017;65:127–36.
[74] Yingli Solar. Products: solar modules. 2018. http://www.yinglisolar.com/br/products/solar-modules. [Accessed 24 November 2018].

[75] Honrubia-Escribano A, Ramirez FJ, Gómez-Lázaro E, Garcia Villaverde PM, Ruiz-Ortega MJ, Parra-Requena G. Influence of solar technology in the economic performance of PV power plants in Europe. A comprehensive analysis. Renew Sustain Energy Rev 2018;82:488–501.
[76] ANEEL – Brazilian Electricity Regulatory Agency. Solar energy. In: ANEEL. Atlas of electric energy of Brazil. Brasilia: ANEEL; 2008. p. 29–42.
[77] ABINEE – Brazilian Association of Electrical and Electronics Industry. Proposals for insertion of solar photovoltaic energy in the Brazilian matrix. Brasilia: ABINEE; 2012.
[78] Aquila G, Rocha LCS, Pamplona EO, Queiroz AR, Rotela Jr P, Balestrassi PP, Fonseca MN. Proposed method for contracting of wind-photovoltaic projects connected to the Brazilian electric system using multiobjective programming. Renew Sustain Energy Rev 2018;97:377–89.
[79] Ertürk M. The evaluation of feed in tariff regulation of Turkey for onshore wind energy based on the economic analysis. Energy Pol 2012;45:359–67.
[80] Brigham EF, Houston JF. Fundamentals of financial management. 11th ed. Florence: Cengage Learning; 2007.
[81] Johnson BE. Modelling energy technology choices. Which investment analysis tools are appropriate? Energy Pol 1994;22:877–83.
[82] Petkovic D, Shamshirband S, Kamsin A, Lee M, Ancic O, Nikolic V. Survey of the most influential parameters on the wind farm net present value (NPV) by adaptive neuro-fuzzy approach. Renew Sustain Energy Rev 2016;57:1270–8.
[83] Sharpe W. Capital asset prices: a theory of market equilibrium under conditions of risk. J Finance 1964;19(3):425–42.
[84] ANEEL – Brazilian Electricity Regulatory Agency. Technical Note nº 33/2016–SGT/ANEEL, http://www2.aneel.gov.br/aplicacoes/audiencia/arquivo/2016/005/documento/ntecnica_33_sgt_ap_caiua.pdf. [Accessed 23 November 2018].