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Trends in multicriteria decision-making models for solar dryers

Tendencias en los modelos de toma de decisiones multicriterio para secadores solares

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Abstract

This research provides an overview of multi-criteria decision-making models, as well as the most commonly used criteria for the development of solar dryers. Mathematical models for decision making based on the selection of multiple criteria have been part of technological developments for years in various sectors of the industry. Solar dryers have been extensively analyzed, developed and classified by several authors, within these classifications we find the hybrid solar dryers (SDH) which provide more stable temperature inside the drying chamber due to an alternate source of energy that may or may not be renewable. Through a bibliographic study we determined which are the most used methods, as well as the classification criteria used in groups to know which is the trend in the use of these. This study allows an understanding and will provide a vision of the most currently used criteria, making clear which are the areas of criteria for possible research and development.

MCDM, Solar hybrid dryer, Sustainable

Resumen

Esta investigación otorga un panorama general de los modelos multicriterio para la toma de decisiones, así como los criterios más usando para el desarrollo de secadores solares, Los modelos matemáticos para la toma de decisión basados en la selección de múltiples criterios han formado parte de los desarrollos tecnológicos desde hace años en diversos sectores de la industria. los secadores solares han sido analizados, desarrollados y clasificados ampliamente por diversos autores, dentro de estas clasificaciones encontramos a los secadores solares híbridos (SDH) los cuales proporcionan temperatura más estable dentro de la cámara de secado debido a una fuente alterna de energía que puede ser o no renovable. Mediante un estudio bibliográfico se determinaron cuáles son los métodos más usados, así como la clasificación los criterios utilizados en grupos para conocer cuál es la tendencia del uso de estos. Este estudio permite una comprensión y proporcionará una visión de los criterios más utilizados actualmente dejando en claro cuáles son las áreas de criterios de posible investigación y desarrollo.

MCDM, Solar Hybrid Dryer, Sustainable

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Introduction

In this section found the generalities about solar dryers the importance and classification and show a technological general perspective, besides talk about of multi-criteria decision making (MCDM) which is the relance and show general process follow the models for this technic.

A lot of research has been done on the use of drying technology to extend the shelf life of agricultural products. However, the extremely energy-intensive thermal dryers used in the food processing sectors use heat from conventional energy sources like coal, liquid fuel, etc., or electricity. According to estimates, the agri-food processing chain alone accounts for 20% of global greenhouse gas emissions and up to 30% of the world's energy consumption (Mujtaba, 2017).

Open sun drying is a common, practical, and affordable technique used in underdeveloped nations for the drying and preservation of agricultural, food, and numerous other items. However, the drying air flow rate, temperature, moisture levels, heat input, and other external drying parameters are uncontrollable, which leads to an unfavorable drying rate or a longer drying period. The deterioration of product quality caused by wind, trash, rain, insects, and animals is one of the open suns drying method's additional disadvantages (Midilli, 2001).

Everitt and Stanley came up with the original concept for a solar dryer (SD) in 1976. It was a housing unit in the shape of a box with a clear sun cover. This invention's primary goal was to offer a fresh approach that helped address the shortcomings of open sun drying (United States Patent). Decades later, a number of distinguished researchers advanced solar drying technology by utilizing forced and natural circulation as well as auxiliary source heating (such as electricity and fossil fuels) to produce the desired drying characteristics (O.V Ekechukwu, 1999).

Depending on the needs, many kinds of solar dryers are available in a range of sizes and designs. Solar dryers are generally categorized according to the type of product to be dried, air movement mode, solar contributions, air direction movements, and assembly insulation as seen in figure 1 (Mahesh Kumar, 2016).

In a hybrid solar dryer, drying is accomplished during the hours when the sun isn't shining through the use of backup or storage heat energy. This prevents the product from potentially deteriorating due to microbial infestation (B.K. Bala, 1994).

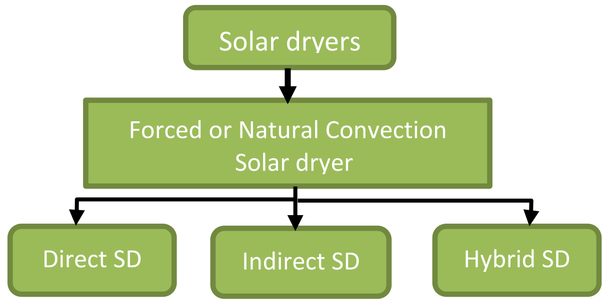

Figure 1 Solar dryer classification
Source: Own elaboration

Using well-built and/or planned devices that can capture solar radiation and maximize its effective usage to dry materials—typically agricultural products—is known as solar drying (Sharma, 2017).

Only in the study of tiny systems can traditional single-objective decision making, which essentially focuses on the maximum or reduction of a certain aspect, remain advantageous. Achieving a system that is perceived as sustainable is more challenging in the current energy planning environment due to the numerous objectives, definitions, and criteria. Thus, in order to combat the growing energy demand while pursuing a vision of sustainable development, an appropriate planning framework that takes into account relevant political, social, economic, and environmental considerations is important (Abhishek Kumar, 2017).

Multi criteria decision making (MCDM) has been shown to be one of the finest tools for effective energy planning in order to tackle such complicated issues pertaining to energy planning. MCDA mostly emerged from operations research, which uses a variety of approaches as show in figure 2 (Murat Köksalan, 2011)

One may see multicriteria decision making (MCDM) as a dynamic, intricate process that involves both administrative and engineering levels of analysis (Serafim Opricovic, 2004)

These models are basically utility based models and include methods like MAUT, AHP, Weighted Sum Method, and Weighted Product Method, these are mostly preferred for ranking energy technologies like application of energy storage devices in the field of renewable energy (Tzeng Gwo-Hshiung, 1992).

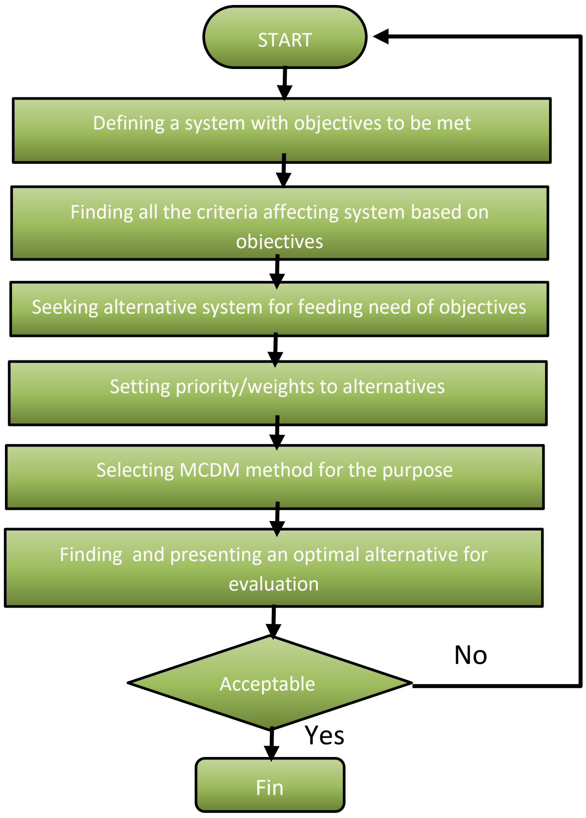

Figure 2 Procedure for MCDM analysis
Source: Own elaboration

Methodology

In this section, we delineate the key words topics and procedural steps that constitute the foundation of this research. We delve into the research process, interpret the systematic methodology employed to gather and analyze data. Furthermore, we elaborate on the tools and methodologies utilized in this study, providing a comprehensive framework.

This section highlights the methods used to prioritize alternatives for solar systems. A detailed explanation of the criteria employed is provided, specifically concerning thermal solar systems, offering a more comprehensive understanding of the factors considered in the evaluation. Additionally, the numerical algorithms associated with the selected MCDM methods are emphasized, providing a fuller comprehension of the analytical tools utilized in the decision-making process within the realm of thermal solar systems.

To reach an objective choice regarding which alternative is best, criteria must be used. Thus, clear and acceptable selection judgments may be achieved by thoroughly thought out and developed selection criteria. To assess how well the alternatives performed, the research used four criteria—social, economic, technological, and environmental. Several criteria were determined and chosen in order to assess the options from a certain angle. The most important stage of the MCDM strategy is this one, which should be selected in consultation with the decision-makers.

The steps to obtain of frame of reference have a next points

1) Use keywords in the principal science data base.

2) Chose de relevance whit the topic.

3) Analyze the paper or book.

4) Select the MCDM and criteria.

5) Administration of data.

After this process we watch general panorama from the studies in this topic as seen in the figure 3.

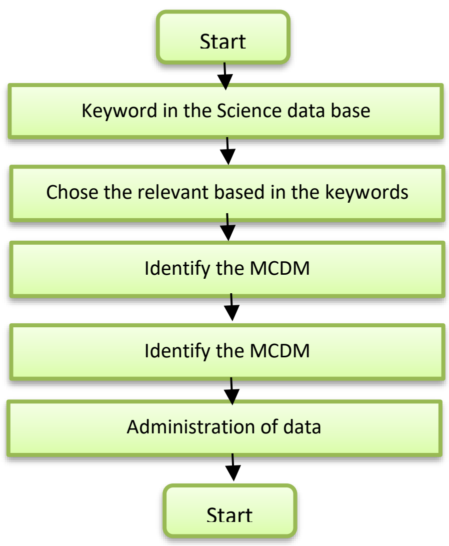

Figure 3 Procedure for MCDM analysis
Source: Own elaboration

This process is followed until no more relevant data is found in the data base.

Results

In this section shows the results obtained from the process of the mythology highlighting which were the mains Methods in MCDM and the principal criteria.

For the search use the next keyword: “MCDM DRY”, “SOLAR THERMAL MCDM” and “MCDM SOLAR DRYER” the search show as around 1120 documents, but only 15 have the relevance as show in table 1.

ID	Author	Title
1	(Ashutosh Chauhan, 2021)	Optimization of pineapple drying based on energy consumption, nutrient retention, and drying time through multi-criteria decision-making
2	(Jorge Meza-Jiménez, 2009)	Low-Cost Solar Thermodynamic Drying System for the Dehydration of Roselle (Hibiscus sabdarifa L.)
3	(Ali Mostafaeipour1, 2020)	A Model Identifying Factors Affecting the Sustainable Use of Solar Dryers: A Case Study
4	(Shweta Singh, 2022)	Analysis of mango drying methods and effect of blanching process based on energy consumption, drying time using multi-criteria decision-making,
5	(Rohit Khargotra R. K., 2023)	Design and performance optimization of solar water heating system with perforated obstacle using hybrid multi-criteria decision-making approach
6	(Huiru Zhao, 2014)	Selecting Green Supplier of Thermal Power Equipment by Using a Hybrid MCDM Method for Sustainability
7	(Rohit Khargotra R. K., 2023)	Optimal thermochemical material selection for a hybrid thermal energy storage system for low temperature applications using multi criteria optimization technique
8	(Jinying Zhang, 2019)	Decision framework for ocean thermal energy plant site selection from a sustainability perspective: The case of China,
9	(Xiaoyan Qian, 2021)	Fuzzy Technique Application in Selecting Photovoltaic Energy and Solar Thermal Energy Production in Belt and Road Countries,
10	(Audrius Ruzgys, 2014)	Integrated evaluation of external wall insulation in residential buildings using SWARA-TODIM MCDM method
11	(Wang, 2022)	Comparative Study of the Thermal Enhancement for Spacecraft PCM Thermal Energy Storage Units
12	(Frattini, 2021)	Fibre-Reinforced Geopolymer Concretes for Sensible Heat Thermal Energy Storage: Simulations and Environmental Impact
13	(Yeliz Simsek, 2018)	Sustainability evaluation of Concentrated Solar Power (CSP) projects under Clean Development Mechanism (CDM) by using Multi Criteria Decision Method (MCDM)
14	(Cavallaro, 2010)	Fuzzy TOPSIS approach for assessing thermal-energy storage in concentrated solar power (CSP) systems
15	(Wenye Lin, 2019)	Multi-objective optimisation of thermal energy storage using phase change materials for solar air systems

Table 1 Highlights papers for dryers or thermal process
Source: Own elaboration

The methods used for solar dryers and thermal processes used by the authors of table 1, TOPSIS, MOORA and AHP are the most used methods as seen in figure 4.

On the other hand, the criteria shown in Figure 5 are grouped because they have specific sub-criteria for each decision making, with the technical criteria being the most important according to the average made by the authors of Table 1.

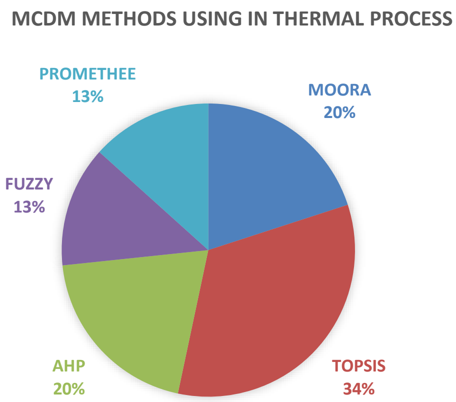

Figure 4 MCDM using in thermal process
Source: Own elaboration

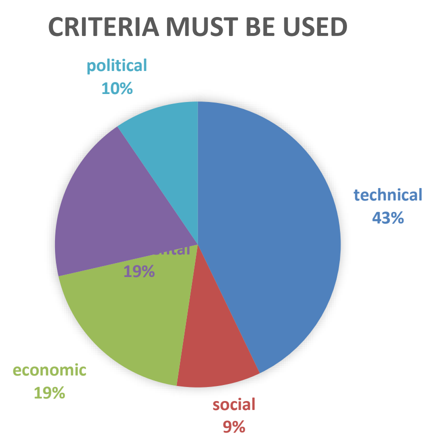

Figure 5 Criteria used by author of table 1
Source: Own elaboration

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Conclusion

According to the research, solar thermal systems have been poorly evaluated with MCDM due to the low evaluation, articles on thermal processes were selected to have a more representative sample, although various MCDM studies for electrification, solar dryers have an area of opportunity for optimization through the MCDM process.

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