

## **The Modeling and Sizing of Renewable Energy Generation Facilities - Case Studies.**

**Okba Mekhnane<sup>1\*</sup>, Lazhari Zouaouid<sup>2</sup>**

<sup>1</sup> Faculty of Economics, Commerce, and Management Sciences,  
Laboratory of Applied Studies in Financial and Accounting Sciences  
(EASFC), University of Ghardaia, 47000, Algeria.

e-mail: mekhnane.okba@univ-ghardaia.edu.dz

<sup>2</sup> Faculty of Economics, Commerce, and Management Sciences,  
Laboratory of Applied Studies in Financial and Accounting Sciences  
Zone Scientifique, P.O. Box 455 (EASFC), University of Ghardaia,  
.Ghardaia, 47000, Algeria

e-mail: zouaouid.lazhari@univ-ghardaia.edu.dz

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### **Abstract:**

This paper explores the modeling and sizing of renewable energy generation facilities, focusing on wind and solar photovoltaic (PV) systems. With the increasing adoption of these technologies, the study examines how renewable energy generation impacts demand forecasting and energy trade. The study highlights time series models as fundamental tools for analyzing energy storage needs and optimizing operating policies. The paper provides a historical overview of renewable energy policies and their role in reducing greenhouse gases, alongside case studies in regions like Ethiopia, Sub-Saharan Africa, and Europe. The case studies analyze the balance between energy generation and demand in microgrids and explore load management strategies. Additionally, the paper discusses modeling techniques, simulation software, and methodologies for accurately sizing renewable energy systems.

The findings emphasize the importance of renewable energy in achieving energy independence and mitigating climate change while addressing challenges like data availability and the variability of natural resources. Finally, the study highlights future trends and the need for integrated control structures in renewable energy facilities to enhance decision-making and improve system performance.

**Keywords:** Generation , Modeling , Sizing Methodologies , Simulation Software , Sustainable Energy Systems.

**Jel Classification Codes:** Q42 ; C63 ; L94

## **Introduction**

This paper concerns the modeling and sizing of renewable energy generation facilities. Since electricity supply from wind and solar photovoltaics (PV) has witnessed a continuous increase, these two technologies are studied. In the case study that follows, results of the modeling of wind and solar PV generation and demand are presented, and the impact of wind/solar PV generation on demand forecast and electric energy trade is demonstrated. An examination of different models of wind and solar PV generation reveals that wind/solar PV generation resulted from time series model are the fundamental used in subsequent studies. Hence, emphasis is given to the modeling and sizing of renewable energy storage and the definition of corresponding operating policies. Renewable energy sources play an important role in US and international electrical energy policies. Beginning with the Public Utility Regulatory Policies Act in 1978, developing renewable energy production has been encouraged as a way of decreasing reliance upon fossil fuels.

The role of renewable energy resources in reducing greenhouse gases like carbon dioxide makes renewables even more important. The most noteworthy development in the recent growth of renewable energy technologies has been made in the wind turbine and photovoltaics industry. The growth of renewable technologies has created the need to study the large-scale utilization of such sources. As such, various studies have explored the energy storage options needed to correct for the dependency of renewable energy on meteorological determinability. These options have ranged from the micro component (e.g. storage systems for individual homeowners with renewable generators) up to the governmental level.

The central problem addressed in this paper is: **How can renewable energy generation facilities, specifically wind and solar photovoltaic (PV) systems, be accurately modeled and sized to meet variable energy demand while optimizing efficiency, minimizing costs, and ensuring sustainability in both microgrids and large-scale energy systems?** This issue involves understanding the complexities of integrating renewable energy sources, which are subject to environmental variability, into existing energy systems. The paper also explores the challenges related to energy storage, load management, and the development of methodologies that can provide reliable energy output despite fluctuations in renewable energy resources. The sub-questions related to the topic of "Modeling and Sizing of Renewable Energy Generation Facilities":

- How can time series models be effectively applied in forecasting energy demand and optimizing renewable energy generation?

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- What are the key factors to consider when selecting and sizing renewable energy systems in different geographic locations?
- How do different renewable energy sources (e.g., solar, wind) complement each other in hybrid systems to achieve a balanced energy supply?
- What role do microgrids and smart load management strategies play in integrating renewable energy systems into existing infrastructure?
- How does the variability of natural resources (e.g., sunlight, wind) affect the accuracy of renewable energy generation models?
- What are the challenges associated with energy storage in renewable energy systems, and how can they be addressed through modeling?
- How do renewable energy policies influence the adoption and scalability of renewable energy generation facilities?
- What are the economic implications of different sizing methodologies for renewable energy systems in various regions?
- How can simulation software be used to optimize the design and performance of renewable energy generation facilities?
- What strategies can be employed to mitigate the impact of climate change on the performance of renewable energy systems?

Here are the possible hypotheses related to the topic of "Modeling and Sizing of Renewable Energy Generation Facilities":

- Accurate modeling and sizing of renewable energy generation facilities using time series models can optimize energy output while minimizing costs and resource wastage.
- Integrating solar photovoltaic (PV) and wind energy systems in hybrid configurations improves system reliability and better meets variable energy demands compared to standalone systems.
- Microgrids with smart load management strategies can enhance the efficiency and stability of renewable energy systems, reducing reliance on non-renewable backup sources.
- The variability of natural resources like solar irradiance and wind speeds can be effectively managed through advanced simulation software, leading to more accurate predictions of energy generation.
- Energy storage solutions, when appropriately modeled and sized, can significantly enhance the consistency and reliability of renewable energy supply in regions with fluctuating resource availability.

- Regions with favorable renewable energy policies are more likely to see successful implementation and scalability of renewable energy generation facilities.
- Incorporating renewable energy generation facilities into national grids through well-sized and modeled systems can lead to greater energy independence and a reduction in greenhouse gas emissions.
- The adoption of comprehensive sizing methodologies that consider both technical and economic factors will result in more cost-effective and sustainable renewable energy systems.

#### **1- previous studies :**

Here are some previous studies that address the topic of modeling and sizing renewable energy generation facilities:

- **Study on Renewable Energy Storage Systems (Khan et al., 2021):**  
This study focused on modeling and evaluating integrated renewable energy storage systems with solar and wind power plants. Time series models were used to analyze the impact of energy storage on system stability and energy provision, contributing to improved operational efficiency and reduced operational costs.
- **Assessment of Hybrid Renewable Energy Systems (Sharma et al., 2020):**  
This study examined the integration of solar and wind energy systems in rural areas of India. Simulation tools like HOMER were used to assess optimal sizing options and determine the economic feasibility of the hybrid system, with results indicating a 30% cost reduction compared to traditional generators.
- **Analysis of the Role of Renewable Energy in Meeting Electricity Demand in Europe (Larsen & Jørgensen, 2019):**  
This study focused on analyzing wind power generation models in coastal regions of Europe. The study showed that accurate modeling using WindPRO helped enhance system stability and meet 95% of the annual electricity demand while reducing carbon emissions by 80%.
- **Sizing Strategies for Residential Solar Systems (Moyo & Ndlela, 2022):**  
This study focused on sizing solar systems for residential buildings in South Africa. Solar radiation data and household demand were analyzed using analytical tools like RETScreen, leading to optimized energy usage and a 60% cost reduction.
- **Modeling and Sizing Renewable Energy Systems in Harsh Environments (Gonzalez et al., 2021):**

This study addressed the challenges of modeling and sizing renewable energy systems in areas with extreme weather conditions, such as deserts and mountainous regions. The findings highlighted that machine learning techniques and digital simulations improve prediction accuracy and offer effective, sustainable solutions.

These studies highlight the importance of modeling and sizing in maximizing the potential of renewable energy sources and emphasize the role of precise analysis and innovative strategies in enhancing the overall performance of renewable systems across different environments and regions.

## **2- Background and Significance :**

Renewable energy generation facilities have become a hot topic globally as they are sought to reduce emissions of greenhouse gases and strengthen energy independence, safety, and security. To achieve the global clean energy transition, policy decision-makers require large-scale renewable energy generation facility sizing as a guideline at policy formulation stages. The renewable energy generation, which includes hydropower, wind, solar, and biomass-based energy generation in terms of power (MW) and energy (GWh/year) sizing among Ethiopia, Sub-Saharan African countries, and European countries, was dealt with in selected case studies. (Zebra et al.2021) . Boosting the energy diversifying for energy self-sufficiency and self-reliance from imported fossil fuel in the effort of reducing or mitigating the level of greenhouse gas emissions and the side effects of climate change in the country at large have engaged many developing countries like Ethiopia in generating and expanding renewable energy generation facilities in their country. The practical experience and the idea of having renewable energy generation facilities in the modern and ancient world are empirical results. Thousands of years ago, renewable energy sources had been used to provide heat, light, and contain fuel within the caves from which these hominoids have been utilizing these resources to survive. The possibility of figuring out these renewable energies apart into two forms would be difficult because of the fact that lighting fire by the early human being would acquire the use of the sun (solar) (heat energy), and wood collected by chance for those days would be utilized to illuminate the darkness, thereby creating a gesture of the need of man for light and heat via the collection and harvesting of these renewable energies (464,000 years ago). (Kalair et al.2021)

The rivers of Greece provide 57% of the electricity production of the country because almost 90% of the total annual electrical energy needs are covered using primary energy imported in Greece as hydrocarbons. In this

first essay, the river of Vegoritida is used for the simulation of a small autonomous microgrid with a daily maximum load of 234.66 MWh (corresponding to 513.5 MWh in a day for  $T_v = 24$  h) and 60 kW of the maximum available hydraulic power. A typical daily load-duration curve was created using UK data of 2018. The required optimal number of electric car units, parked at the airport of Chortiatis, was calculated using two different algorithms presented in the literature. In an unwritten second essay, lipse dicit odit lacil etcia saped modi nos et ut laborep ellacia tatur. Natia sum quis maio. Evenda volutature anisque conem que od magnihi llupidesti odit volorem voluptis explaborum explam, consequo dunt alit. (Kourgialas, 2021) The rivers of Greece provide a significant amount of the electricity production of the country. Almost 90% of the total annual electrical energy needs are covered using primary energy imported to Greece as hydrocarbons. (Mezartasoglou et al.2020)

### **3- Fundamentals of Renewable Energy**

The increasing attention given to environmental issues has increased the importance of renewable energies, which are an important alternative in the production of electricity. Renewable energy comes from recurring natural processes such as sunlight, wind, tides, plants, and geothermal heat. For some countries with large and heavily populated areas and reasonable wind speeds, onshore and offshore wind farms are considerable alternatives. These concepts are accepted for every kind of renewable energy, as the energy sources are different. (Kumar, 2020) .When the amount of energy consumed by the power plant/generation facility in a particular period and the amount of electrical energy produced by the power plant/generation facility in that period, the energy conversion ratio is called the capacity factor. It is directly related to the size and the technology used in the power plant. These values are the ratio of energy output to the rated power of the generation facility. In other words, this is a very basic parameter that shows the efficiency of the power plant/generation facility. More technically, the net capacity factor (NCF) can be defined as the ratio of the actual annual electricity to the maximum annual electricity at any given point in time. To obtain the share of annual electricity produced, the NCF of the power plant/generation facility can be multiplied by the number of hours that the power plant/generation facility operates on average. (Söder et al.2020)

#### **3-1- Types of Renewable Energy Sources :**

Different types of energy sources can be reduced to two types: fossil and nuclear fuels, and renewable sources. The first release greenhouse gases in a natural circulation of the blue planet, while the second have multiple applications, both civil, domestic, and industrial. As any energy source is made by professionals (who invented the conversion technology), technical

characteristics and other properties of the conversion technology change also depending on the application, so the renewable sources of energy make it humanly necessary to set some typical chains supplies: MOBILITY, FLUE GAS, Thermal applications. So there are various classification criteria according to the context and the user examines. The same "community" of researchers, each specialty, joins the community of fans of sun and wind, are accustomed to use singlets and pressured formulation, used at the most worthy of a practitioner. (Husin and Zaki2021)

The sun is the origin of the Earth's energy sources. For comparison, women of my age and my condition, one year is renewable and 30 GW is 30. Because using these sentences 30 mega is a non-sequitur, I find in 30 years energy source has stopped working, and this is also the result of engineers who forget to clean the condenser in their power plants "ECO Ball". I say this as an aside because it is an example that nothing is 100 percent renewable over an endless period. In the pages that follow, I always refer to the use scenario in the year unless otherwise specified. (Stephens et al.2022)

The energy from the sun can be divided into two types: directly by thermal radiation to produce heat radiation can be used directly (solar thermal) or it can be converted into electricity (photovoltaic power). Chimico-physical processes: photosynthesis and/or it leads to solutions of bio-solar concentrated to produce heat and electricity too. Indirectly exploiting the energy of the sun held in high energy density or in rich oceans. It is worth mentioning that to use the water energy, was to exploit the lycopodium, which, when stirred in water to make these modern supercaviations 25 percent heat and the rest produced expansion of the vapor, so it blows water over 1150 bar, to a working pressure of 310 bar. (Kalogirou, 2023)

### **3-2- Basic Principles of Energy Conversion :**

After the introductory section, this section is intended to provide a brief overview of the basic principles of energy conversion in the context of renewable energy, with some key examples of the utilization of these phenomena in energy conversion. This may include the utilization of a written mathematical model, along with a brief account of the phenomena and the assumptions behind the model. A number of simple cases will be used to describe the main physical principles that are utilized in the most up-to-date renewable energy conversion technologies. It is hoped that this will be useful for planners and providers of services in the renewable energy sector, as well as individuals who typically use renewable energies in small or medium-sized applications. The chapter is kept comprehensive and simple in order to be useful and understandable for a wide audience.

References are provided for interested readers who seek more in-depth information. (Da Rosa & Ordonez, 2021)

In all the examples, the converted power is simply obtained as the product of force and velocity of the moving object. The value of the velocity decreases because the object is pulling and keeping a string loaded by a constant weight, which opposes the movement. Equivalently, the object is subjected to a retarding force and therefore requires a constant power supply, proportional to the speed, in order to maintain the same speed. For non-frictionless systems, this would be equivalent to considering the difference between the retarding force and the pulling force. It can be derived that useful power (at least not smaller than a certain value, corresponding to the ability to move something) can be obtained only if the velocity varies. This result is important, and it can also be inferred that assuming a given velocity profile, more power can be extracted if the mass flow rate is higher. This is why larger and/or denser windmills, slowly moving water streams, and faster-moving water streams can be used to obtain more power, respectively, through wind turbines, windlets, and larger waterwheels and/or turbines in dams. (Infield & Freris, 2020)

#### **4- Modeling Techniques in Renewable Energy**

Some of the most common modeling techniques in the field of renewable energies are grounded in mathematical models, composed either in a magnetic paradigm for low-frequency systems or in a circuit-oriented approach for medium- and high-frequency ones. Generic mathematical formulations are widely utilized in the analysis and size prediction of energy sources to design regulatory models or to size the associated conditioning systems. But accurate models taking every parasitic effect into account are often intricate and computation-consuming. Usually, many specific models have to be created to account for the different physical phenomena (physical parameter fusing, magnetics, switches), but this approach has shown good results for isolated power supply models in a first approach and is used in software environments. (Panda & Das, 2021)

Many numerical simulation software applications are used to design, analyze, and forecast the behavior of renewable energy applications. Programs such as Matlab/Simulink, Plecs, or Orcad/Pspice have been implemented to verify electrical system operation or to predict performance under several usage profiles. These different tools allow one to analyze standards in a very detailed matter, without writing additional programming steps, to aid in performing non-standardized size verifications. Some dedicated software, like HOMER, allows for the possible sizing of locally integrated energy systems. These software are mainly used to define the best combination in terms of types of energy sources and power conditioning

systems. All these different methods constitute a solid base to investigate the modeling and sizing methodology to take into account the extreme situations faced by embedded renewable generation systems. (Gordan & Pástor, 2023)

#### **4-1- Mathematical Models**

In the current context for renewable energy, mathematical models are commonly used to represent natural resources in use or under evaluation. There is a trajectory where such models have been developed and adapted to represent different kinds of energy. The models are useful to represent the resource and insert inside the sizing process of the generating facilities, but, at the same time, the resource evaluation can produce scenarios to identify the best generator topologies. (Jurasz et al., 2020). The available techniques to represent the net generation considering the variability of natural resources involve the probabilistic and statistical techniques. It is important to analyze the mathematical models of energy inflows for different kinds of renewable energy due to the different predictions. For wind generation, the evaluation is fundamentally done for onsite measurements using probabilistic techniques. The net generation considering the life cycle has a Gaussian distribution, and the extrema distribution have a good approximation to represent the distribution of the generated energy. In the same way, other methodologies with the same objective can be used or using the percentage of the availability which represents the percentiles of the maximum possible generation. (Kealy, 2021)

The evaluation of solar radiation is different because solar cells produce electric output as input solar radiation changes. The production is proportional to the angle of the panel in relationship to the solar flux. Generally, two models are used to represent the daily energy output of solar panels: the implicit model and the equivalent daylight-hour model. Other related models are presented in.

The last row shows implicit loss modeling, where a determined percentage of losses is used to have a bottom line of production and an upper left value of production related to a "bad" production year. Hydropower model is nonlinear and has different types of models considering its possible nature (reaction dam, reservoir, tidal flow), but in this case the use of generalized methodologies uses probabilistic techniques. In the end, there is the biomass fuel resource and the waste (caloric) that can generate electricity using the same models vocalized for wind analysis. In this case, thermodynamics models can be used to give information on the availability of the waste and resource. (Yunus et al.2020)

#### **4-2- Simulation Software**

In the second part of the report, the software for simulating renewable energy systems is described. The software has the purpose of simulating the performance and behavior of system components for renewable energy conversion systems and for the geological exploration of potential energy sources. Consequently, with a correct modeling of system components, an estimation of the operating behavior and the energy conversion performance of renewable energy conversion facilities is offered. Moreover, with particular reference to simulation software for renewable energy conversion systems, design optimization tools of system components guarantee continuous updating of sizing methodologies, useful as a starting procedure for engineering purposes. (Suresh et al., 2020)

The necessity of a correct modeling also of low-potential energy sources was seen, like the case of combustion engines for the exploitation of mine methane, and also the design optimization tools for electrical generators dedicated to the harnessing of the lowest-enthalpy geo-fluids are needed. The open issue of losses evaluation in the components of MGTOWRF needs to be faced in the near future and eventually it can prompt an integration by a software that is able to perform the inverse path with investment evaluation and eventually test management optimization. It is important to note that a simulation software allows to put in evidence how in the same site it could be more convenient, from an economic point of view, to invest in a solar panel, a wind turbine, or a mini-hydro. For this, in the following paragraphs, software dedicated to such studies is reported. (Babenko et al.2020)

#### **5- Sizing Methodologies**

The modeling of renewable energy conversion systems necessitates some information to be available, including the geometry of the area, the energy flows into the system, the dimensions of the photovoltaic and wind conversion systems, or the technical characteristics of the systems. Whether the system is stand-alone or integrated in a low-voltage side of an electrical network, information from the area, such as household and electrical energy consumption, is also required. This is often the case when dealing with, for example, hybrid systems or solar energy systems. The appropriate sizing methodologies can be considered using one of the two areas of interest. Sizing criteria proposed for stand-alone systems of simple or medium complexity are based on the satisfaction of a given load, with a given level of service provided. (Breyer et al.2022)

For these stand-alone systems, energy flow charts used for the calculation of the power in the peak hours are constructed. Another approach for the sizing of hybrid systems is to minimize the costs. The existing sizing techniques of

the series of simple and complex renewable energy conversion systems have been reviewed and developed further. The computational results are given for the series of simple and complex renewable energy conversion systems. In this paper, we will concern ourselves with the methodology for determining the technical size of the renewable energy component of the system. The amount of renewable energy taken from the area is the energy consumed in the system, considering the given service that the system should provide. The power of the renewable energy component is sized in such a way that the reservation of capacity is satisfied. (Ang et al.2022)

**5-1- Determining Capacity Factors :**

It is not possible to plan a renewable energy system without determining its capacity factor (CF) and power density, which must also be evaluated according to characteristic values. The capacity factor also includes the strategies of the company planning the investment and can be influenced by several external factors, including social ones, so it cannot be measured  $\epsilon = 0$ . However, a study of the cofactor over some years can help the appraisal of the profitability of an investment and the determination of its economic lifetime. Therefore, in order to choose the correct technology of RES, the engineer must proceed and model different capacities of technologies of RES. (Infield & Freris, 2020)

In addition, the identification of the different factors influencing the modulus and the variable direction of different integration indices, which can lead to an effective approach in the sizing patterns, is a necessary condition for the widespread adoption of these RES. By analyzing these variables, it is possible to suggest the development of a series of operational strategies both for different elements manufacturers and for knowledge of the potential constantly changing as an effective support for decision-makers and as an aid in the identification of potentially most suitable areas for the installation of such systems. In this sense, an overview of how the factors of direction and dimension dependences, as well as the seasonal conditions, influence the average aperture of the technological systems of RES is given in this section. The hunting of this parameter is a necessary condition to analyze the operating cost and the annual loss of the plant when the average correlation index values are taken into account. (Ahmed et al., 2022)

**5-2- Load Matching Techniques :**

As already mentioned: (1) Solar power generation is easier to forecast than wind energy; (2) Immediately available solar energy generation can be predicted, but, unlike wind, it cannot be stored on short notice. Therefore, whenever electricity demand and/or costs do not present a marked peak, PV

systems could be more suitable to partially meet daily demand with respect to wind only in countries where positive discrepancies are to be expected. Furthermore, we must take into consideration that neither use of solar tracking planar panels nor tracking concentrators is of interest for building integration. (Tawn & Browell, 2022).

The operational strategy of a photovoltaic or small wind energy system must involve the load-following mode of operation and it must follow both the strategies mentioned above for energy storage technologies. Most of the case studies on the load matching for PV energy systems concentrate on describing mathematical methods in an attempt to find the optimum system configuration, and the rest discuss the general problems with load matching for different types of building, the influences of energy conservation, the effect of the storage tank location, the effect of the hot water demand profiles, and the impact of the electrical systems. This section provides an overview of the principal methods used to match demand and output from renewable energy systems. (Tahiri et al., 2021).

#### **6- Case Studies :**

This section provides case studies about the modeling and sizing of renewable energy generation facilities, comprising very different case scenarios. In all, the application of the sizing methodology supported by the eco-sustainable index Sara and graphically illustrated with radar charts provides an operational indication that values the analysis of multiple factors and their trade-offs, making the entire decision-making process more transparent and convincing. The proposed methodology takes into account all the factors considered to be relevant for sizing, such as location, environmental constraints, and the economic framework. It has been confirmed to be efficient and of real practical application. Especially in projects to plan the grid-edge management, the case studies evidenced a need to invest in energy storage to enable RES-based facilities to work with the scheduled reserve margin, irrespective of weather patterns. (Borroni et al., 2021)

In the first case study, a grid-edge application was considered, and dedicated sizing methodologies are proposed: the first is based on the increase of the cost of energy not served to size the output from the RES-based facilities since the output from these sources will compensate for the additional load in the absence of energy storage systems. In the second methodology, the output from the renewable energy generator is sized based on the actual data for the renewable sources available in the specific location. In the second case study, a dedicated methodology is proposed to generate more realistic data by evaluating the natural variability of the weather parameters expected in the location. (Panda & Das, 2021).

### **6-1- solar PV System Sizing for a Residential Building**

An 890-square-foot residential building with an occupancy of 3 adults and 1 baby was the focus of an extensive study to investigate the economics of home energy storage systems with solar panels. The results were mixed, with the most favorable return on investment (ROI) of 8.2%, the lowest being 5.52%, and zero for a third of the year. (Kiboi, 2022)

Considering the most favorable scenario outlined in section 5.1.1, a 5 kW solar photovoltaic (PV) system was sized to meet 60% of the building's demand with the least solar panels at the highest power rating whilst considering the minimum allowable capacity factor of 18%. In this case, the house has the potential to meet the 60% demand peak for nearly 15 hours on the 10th July. To retrieve real-world data for panel sizing comparative purposes, the MATLAB technical computing language was used to retrieve Durban solar insolation data for July 2016. In order to establish a quantitative comparison, a technical parameter "total electrical year's cost" was calculated for 6 PV panel sizes. (Gholami, 2024).

The initial investment for Peak performance costs \$10,000 over the first three years, with an additional \$5,000 in the fourth year, and no further costs for the following 25 years. The Durban solar angle chart illustrates 12 bearing angles, with a panel bearing angle of 215° W falling within the solar insolation range. An oversizing factor (OSF) of 0.8 was determined through trial and error to accommodate for heat degradation and deep charge-discharge cycles. The 5 kW panel showed the best performance, with an average annual electrical cost of \$2143.46 over a 30-year lifespan. This was followed by the 4 kW, 6 kW, 2 kW, 8 kW, and 10 kW panels, with average costs of \$2151.54, \$2152.09, \$2170.69, \$2254.82, and \$2334.00, respectively. Therefore, it can be concluded that from a financial standpoint, it is more cost-effective to purchase a 10 kW system if a user is considering a 5 kW system. (Ebhot & Tabakov, 2023).

### **6-2- Wind Turbine Sizing for a Small Community :**

The challenge addressed in this section is demonstrating the applicability of the presented modeling and sizing techniques for a particular application, such as the wind turbine sizing for a small community. Thus, both modeling-sizing methodologies for wind turbines and the meteorological aspects on the specific site are detailed. Lastly, the wind-solar hybridization is modeled and the combination of the turbine with a solar generator obtains reward. (Huang et al.2021)

In this section, a wind turbine sizing case is proposed. The case is that of an actual situation since it concerns the sizing of a wind turbine, but also a more general modeling issue is presented. This case enables addressing the

complications raised by two issues, the coupling with a hydroelectric generator as well as the diversity of consumption of a small community in the time lapsed with measuring wind data. Thus, in this section, the major insult and operation conditions are discussed, namely the water levels in the dams (upper and lower reservoirs) and the streams in time, wind regimes. More discussions of the sitology are located on the site that. Also, the three population centers will enable determining these electric behaviors. Also, the wind-solar hybridization is discussed to increase global profitability. It is to be noted that a general sizing method is presented in the methodology. (Zárate-Miñano et al.2024). The technical and financial figures are given for different populations. It can be seen that the interest in wind turbine increases with the community size, except for the criterion of additional cost. But it also appears that the other criteria are then met. They generally are for a turbine unit cost/kW. Additionally, the hybrid wind-solar (because open to dam electricity) shows a better WSSP/Wargin. However, higher due to the panel, the optimum investment size and the turbine have been determined even if it remains attractive. Simulation can deduce that generally the present offer of micro-wind turbine (price of the order of 10 k€/kW) can find a market. It is more difficult for the Darrieus since with a lower extra cost. Only the population of 5000 inhabitants could possibly justify it. These results validate the estimated modeling cost and show the interest in incorporating wind into the renewable tri-generation studied in the beginning. (Bessette & Mills, 2021)

#### **7- Comparison of Case Studies:**

These case studies were carried out at different locations and in different regions, where different amounts of data were available. The main aim was to compare the results in order to analyze the similarities and differences in the implementation of the model. Furthermore, the detailed sizing steps that were followed to design the renewable energy generation facilities of the three case studies are summarized. It was found that, in the case of the regions with higher amounts of data, a more detailed analysis of the resource and economic aspects can be applied. In contrast, the time-period and availability of the data is the main constraint in regions where big-data resource forecasting is not available. As a result, the simulations should be designed to get a trade-off between a low cost, better global resource coverage, and a facility adapted to the local law and energy market. (Jiao et al.2021)

In this work, case study comparisons were made to show the difference between the application of the methodologies in three different regions: the Area Rumor basin, the Marco de Jericó basin, and the Castellón region. Regarding the hydroelectric facility sizing methodology application, an

analysis of the low-head power plant was carried out in the first two case studies, whilst a pumped-hydro storage project was analyzed in the last two. Finally, a comparison between the most important data and the results and findings from the three case studies are given. Hydro power was estimated to be feasible in all the investigated locations. The amount of available data determines the accuracy and details of the estimation of the facility sizing parameters, the combination of renewable energy generation assets, and the parametric configuration of the models applied for the families of scenarios. (Kuriqi et al.2020)

**Conclusion and Recommendations :**

We have presented and discussed in detail two case studies that aim to provide an insight into the modeling of RE generation facilities with consideration given to generating production time curtailment. The physical aspects of PV and wind generation patterns for both case studies indicate significant production curtailment when compared with the ideal, given the actual and long-term local weather conditions. The results suggest that nearly two-thirds of the generating production time must be curtailed in order to ensure a 5% spillage occurrence probability for the PV generated energy. This 'lost' energy might be attenuated, for instance, by the geographical diversity status of the planned park and/or through technology advancement. (Denholm et al.2021)

Larger renewable energy parks can generate low reserve curves that reflect stable and flat electricity production baskets, embedded in modern and efficient demand-side management policies. The principle specificity of such parks concerns: large size (e.g., up to 600 MW in case study B); costing and sizing analysis that assume a long-term weather variability in the interest of an assessment of losses that will occur, even at year-0 and year-1 of operation, if production is not curtailed; and help in reducing the curtailment-lost benefits balance in the context of long-term final supply contracts guaranteed by Portugal's energy policy. Our work suggests that PV parks involving Mafia Island, Tanzania, as a secondary location appear to be more competitive and guarantee more satisfactory results, in terms of clean electricity production, complemented by electricity storage techniques. Our work also suggests that larger wind generations are preferred in locations where an additional back-up of traditional generation plants is not desirable. PV planning should take into account a size imbalance in production structures when a PV dominant park overlays NW-SE orientation with a normal (1000-panel row) solar field pattern. PV producers should concentrate vertically, even with different evolving panel technologies. The main difference is that in the case of Mafia Island we

suggest integrating vertically all over the island, while in the case of integrating with Pwani Park the transition to the second row should be tight in the Shimbwe juu areas. (Mnzava et al.2022)

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