OPTIMAL ENERGY MANAGEMENT STRATEGY OF DC MICRO-GRID FOR MODERN AGRICULTURE: CASE OF MANDIANA PREFECTURE, REPUBLIC OF GUINEA

by Jana Publication & Research

Submission date: 24-Oct-2025 12:23PM (UTC+0300)
Submission ID: 2772508705
File name: IJAR-54487.pdf (1.03M)
Word count: 3905
Character count: 19541

OPTIMAL ENERGY MANAGEMENT STRATEGY OF DC MICRO-GRID FOR MODERN AGRICULTURE: CASE OF MANDIANA PREFECTURE, REPUBLIC OF GUINEA

Manuscript Info

……………………….

Manuscript History

Received: xxxxxxxxxxxxxxxx

Final Accepted: xxxxxxxxxxxx

Published: xxxxxxxxxxxxxxxx

Key words:-

Solar Photovoltaic Panels (SPP); Battery Energy Storage Systems (BESS); Optimal Energy Management Strategy (OEMS); Pumping Water System (PWS) ; DC Micro-Grid (DCMG).

Abstract

………………………………………………………………

This study delineates a DC Micro-Grid (DCMG) system designed for the rapid distribution of electricity for residential and agricultural water utilization. The Solar Photovoltaic Panels (SPP) do not consistently generate uniform energy output, and the Battery Energy Storage Systems (BESS) should maintain an optimal charge level, avoiding both excessive depletion and overcharging. Moreover, residences must consistently maintain a power supply. We developed an Optimal Energy Management Strategy (OEMS) for our system, encompassing SPP, BESS, household loads, and a Pumping Water System (PWS) in rural regions. The research region, Mandiana, is situated in eastern Guinea, with approximate geographical coordinates of 10° 38' 0" North and 9° 18' 0" West. The system is engineered to fulfill daily energy requirements and was developed via MATLAB/Simulink. The simulation findings indicate that the suggested approach can provide water for irrigation, power for domestic use, and enable battery charging and discharging. It is applicable to any system with a DC load.

…………………………………………………………………………………………………
………....

Introduction:-

According to studies, Africa's population is anticipated to reach 2.4 billion by 2050, accounting for more than half of global population growth over this time period [1]. Globally, the population is expected to reach 9 billion by 2050 and 11 billion by 2100, implying that food production must increase by 70% to fulfill demand [2, 3]. As a result, guaranteeing food security has become a top priority in agricultural research. According to the International Labour Organization (ILO), farming provides a living for at least half of the African population, with over 80% of farmers working on tiny plots of less than two hectares [4]. When agriculture declines, the impacts might extend beyond individual families. A decrease in crop production can disrupt markets and affect people across the country [4]. Agriculture is the primary sector of activity for over 67% of the people in the Republic of Guinea (11º 00' N and 10º 00' W), employing 52% of the labor force [5, 6]. By 2022, his contribution to the country's GDP had risen to 27 percent. However, agricultural potential remains underutilized; food self-sufficiency is still uncertain, and Guinea continues to import a variety of agricultural products, including rice [6, 7]. Due to significant challenges, Guinean agriculture needs a true innovation that incorporates new concepts, methods, and technologies tailored to small-scale exploitation [8]. In this regard, using photovoltaic solar energy in conjunction with a water pumping system to provide a sustainable supply of water is an effective way to stimulate the agricultural sector [9]. This initiative falls under the broader framework of the country's energy policy, as outlined in the LettrePolitique de Développement du SecteurÉnergétique 2012 (LPDSE), which aims to reduce reliance on fossil fuels, increase electricity exports by utilizing Guinea's hydroelectric potential, promote renewable energy programs, and increase energy efficiency [10].

Furthermore, in the case of Mandiana in Guinée, the predominant agricultural activity is the maize culture, which is vital to local food and the rural economy. This region has challenges such as climate change, limited access to electricity, and geographic constraints that affect food security and economic development. Mandiana is a very wet area that is part of the large basin of the Niger River. This location is a plus because the Niger and its tributaries (the Sankarani, the Fié, and the Milo) water the prefecture (figure 1). These rivers water huge, fertile plains that haven't been used yet. Using irrigation for farming could improve these plains. Therefore, the fact that these valleys of fresh water exist is a wonderful opportunity to restart indigenous agriculture with well-designed irrigation systems for food security and crop diversity in Mandiana[11].

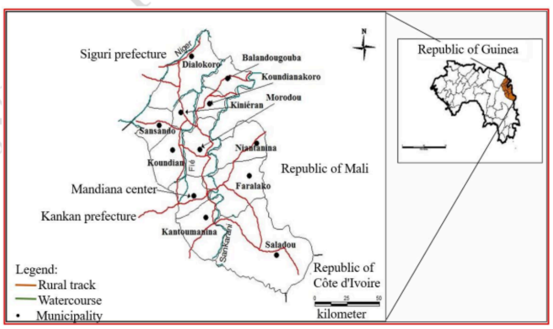

Figure 1 :Location of the study area

These benefits and inconveniences are what motivate us to keep working. In this context, we propose in this study the installation of an autonomous solar photovoltaic microgrid with storage that might help modernize irrigation, improve food security, and electrify rural areas. In fact, sustainable and productive agriculture requires a system-wide concept optimization for optimal water and energy usage, enabling more environmentally friendly and profitable production methods.

Numerous methodologies for energy dispatching have been established in the literature. A Distributed System Operator (DSO) oversees energy management, as seen in [12]. The proposed method makes it possible to manage energy in the coordinated microgrid. A stochastic methodology for the dispatch of the battery energy storage system is proposed [13]. The simulation results show that the suggested method improves the dispatch policy and works better than the other techniques. A lot of different management techniques are used and compared [14]. Because of this, the ANFIS is easier to read. To control the energy of a microgrid, an adaptive controller is used [15]. The authors assert that this technique effectively mitigates the issues of both overutilization and underutilization of an energy storage device (ESD). A new way to manage is created[16]. The goals of this strategy are to cut down on CO2 emissions, employ more renewable energy sources, and lower the overall cost of the microgrid. An energy management model is used for a microgrid that has PV panels, a diesel generator, and a battery bank [17]. The system's performance is shown to be good after being simulated in MATLAB. Adefarati et al. [18] decreased the energy and operational costs of the diesel generator and battery storage system while maximizing the benefit/cost ratio. The methodology employed, as stated by the authors of [18], is applicable to both residential and commercial structures. Clarke et al propose a two-layer economic model that reduces operational expenses and CO2 emissions [19]. A multilayer supervisory system has been devised [20]. This technique accounts for the power requirement of the load. A supervisory system is meant to optimize power output from the photovoltaic source, safeguard the battery against overcharging and deep discharging, and meet energy requirements. In [21], a novel long-term supervisory prediction system is developed to enhance the practicality and accuracy of SOAP (State Of Available Power) predictions for lithium-ion batteries in electric vehicles. A. Ndiaye et al. in [22] employed Adaptive Neuro-Fuzzy control for battery charging and discharging. A distinct supervision technique has been devised by M. Traore et al. in [23] utilizing an Arduino board to regulate the battery's charge and discharge processes and ensure its protection.

This research formulates and executes an optimal energy management strategy for a Solar Photovoltaic Pumping (SPVP) system with storage, utilizing MATLAB. This approach seeks to concurrently secure the electricity supply for a residence and the irrigation system for a village in the Mandiana prefecture. The innovation chiefly resides in the configuration of the examined direct current system and the specific aims: rural household electrification and irrigation water pumping in Mandiana prefecture.

Methodology

Modeling of the Studied System

The analyzed system (refer to figure 2) comprises a photovoltaic array, an energy storage battery system, a residence with a cumulative electrical load of 260.8 W, and an electric motor. The latter is utilized to irrigate one hectare of maize cultivation. Furthermore, two DC/DC converters are employed to enhance the output power and to increase or decrease the voltage of the photovoltaic system and the battery.

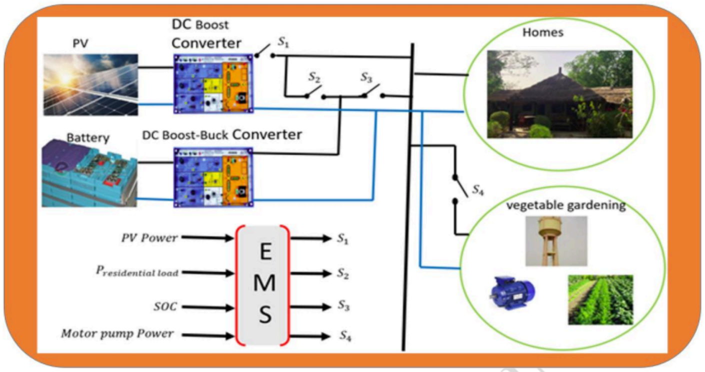

Figure 2: Studied system.

Modelling of PV panels

PV panels consist of PV cells that directly convert solar irradiance into electricity. Numerous mathematical models exist for photovoltaic cells. The five-parameter model is the most utilized (figure 2).

$$I = I_{ph} – I_o[expo((R_S.I+V)/(\mu.k.T)) -1]- ((R_S.I+V)/(R_{sh})) \quad (1)$$

With:

$$I_{ph}=I_{SC}[1+R_s/R_{sh}]+I_O[expo((R_S.I_{SC})/(\mu.V_t)) - 1] \quad (2)$$

$$I_o=[I_{SC} – R_S/R_{sh}]expo(V_{CO})/(\mu.V_t))) \quad (3)$$

where:

I is the output current of PV cell, I_{ph} is the photo-current, I_O reverse saturation current of PN junction (A), k is Boltzmann's constant, I_{SC} is short-circuit current, V_{CO} is open circuit voltage, μ is ideality factor, V_t is thermal voltage, R_{sh} is shunt resistance, R_S is series resistance.

The power generated by the PV is calculated by using the equation (4) [24] and depends on the cell temperature and solar radiation.

$$P_{PV}(t) = P_{m,STC}.G.(\alpha_{PV}(t)/ \alpha_{STC})*10^{-3} \quad (4)$$

$P_{m,STC}$ and α_{STC} the peak power and the efficiency of the PV modules under standard conditions (G= 1000 W/m², air density 1.5, PV temperature = 25°C), $\alpha_{PV}(t)$ efficiency of the PV at time t. The output power generated by the pv also depends on the static converter used [25]. In this work, we used the boost converter. So, the output power of the PV is calculated as follows:

$$P_{PV,out}(t) = P_{PV}(t).\alpha_{dc,con} \quad (5)$$

With $\alpha_{dc,con}$ is the boost converter efficiency.

-**Modelling of battery**

The battery is used to store energy to be used in case of energy shortage. In this paper, the lithium battery is used. The equivalent circuit of a battery is on figure 2.

The equations (6 & 7) give the charge and discharge voltages [26]:

Charging:

$$V_{bat}=E_O - R.i - \gamma[Q.i^{*}/(it - 0.1Q)] - \gamma[Q.i/(Q - it)] + \beta.expo(-B.it) \quad (6)$$

Discharge:

$$V_{bat}=E_O - R.i - \gamma[Q(it + i^{*})/(Q - it)] + \beta.expo(-B.it) \quad (7)$$

where:

E_O is battery constant voltage (V), R is battery internal resistance, i is battery current (A), i is negative during the charge and positive during the discharge of the battery, γ is polarisation constant (V =Ah), Q is battery capacitance (Ah), i^{*} is battery-filtered current (A), β is exponential zone amplitude (V), B is exponential zone time-constant inverse (Ah).

The state of charge of the battery is given equation (8).

$$SOC(\%)=100.(1 - Q/C_{bat}) \quad (8)$$

With: C_{bat}: battery capacity.

To protect the battery, the following contraintsare given to the SOC (see equation 9).

$$SOC_{min} < SOC(t) < SOC_{max} \quad (9)$$

Where:

SOC_{min} and SOC_{max} are spectively the minimum and maximum values of the SOC.

-Modelling of DC motor pump

Two categories of motors exist: AC and DC. These are typically utilized in low-power systems due to photovoltaic technology generating direct current. Moreover, for photovoltaic installations under 5 kW, direct current motors are typically employed [27]. The power required by the motor ($P_{motor,req}$) is determined using equation (10). The equivalent circuit is depicted in Figure 3.

$$P_{motor,req}=P_{HYD,req}/\alpha_{motor} \quad (10)$$

where:

α_{motor} is efficecny of pump,

$P_{HYD,req}$ is hydraulic power required by pump (see equation 11) :

$$P_{HYD,req}=(H.g.\rho.Q_v)/36*10^5 \quad (11)$$

H : head size (m), which is sum of static head (m) and friction losses (m), g: acceleration due to gravity (9.81 m/s2), ρ : water density in kg/m3 Q_v : volume of water required (m3/day).

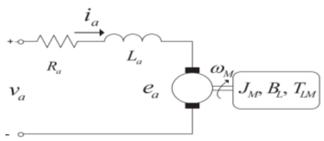

Figure 3: CC motor equivalent circuit

-Energy management Algorithm

This study employs an approach that initially involves the development of an algorithm (figure 4) designed to consider energy distribution and function as a charge controller. This algorithm has four input parameters: photovoltaic (PV) power, residential load, pump power, and the state of charge (SOC) of the battery. The outputs are linked to switches S1, S2, S3, and S4 (refer to figure 2).

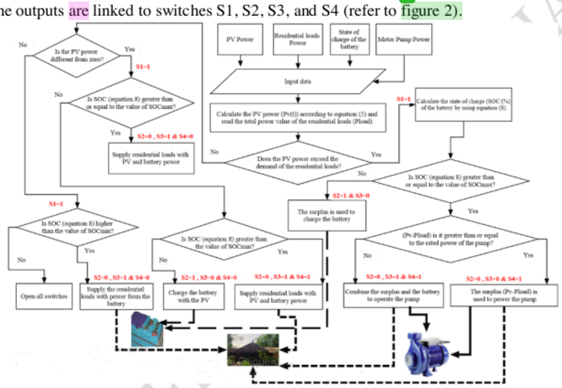

Figure 4: Flowchart of the system power management strategy.

Results and Discussions:-

We recompiled the residential loads of the house to assess the energy demand. The pumping system necessitates a water supply of 3.39 m³/day, with a flow rate of 1.13 liters per hour and a total dynamic head (H) of 27.5 meters. Consequently, equation (11) expresses the hydraulic power as follows:

$P_{HYD,req}$=(27.5*9.8*1.13)/36*10^5

This value leads us to choose the Aquatec SWP-4000 pump whose characteristics are shown in table 1.

Table 1: Pump characteristics

Type of pump	Voltage	Weight	Maximum head pressure (Ft)	Power rating	Maximum ampere	Maximum dynamic head	Efficiency
Permanent magnet DC	12-30 Vdc	4.5 kg	230	110 W	3.7 A	70 m	90 %

The power demand of the pump is known as follows: $P_{motor,req}$= (85/0.9) = 94 W.

In certain scientific studies, simulation software is necessary prior to experimentation. So, in this work, we used MATLAB/Simulink software to implement the system we studied (Figure 5). The simulation uses a total of 400 W for the PV array, 260.8 W for the house's electrical loads, and 110 W for the pump motor. The battery can hold 100Ah.

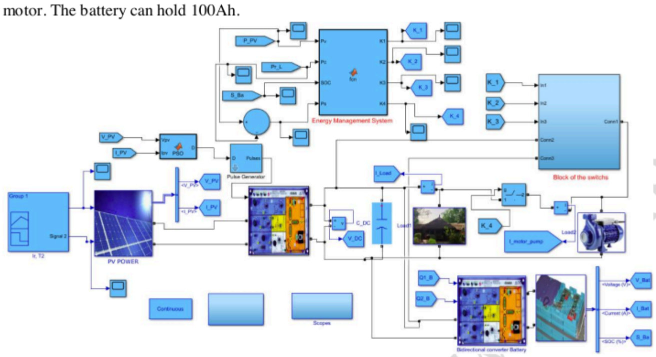

Figure 5: Studied system implemented under matlab/Simulink

Figures 6 to 12 show the results of the simulation. Figure 6 shows how much radiation and heat the PV system is getting. These changes in the weather affect the power output of the photovoltaic system.

The currents of the electrical loads and the motor pump are shown in Figure 7. The pump motor current is zero when it is not powered.

Figure 8 shows the current and voltage of the battery. This figure confirms that the charge current is negative while the discharge current is positive. The voltage varies little with compared to the current during both stages.

Figure 9 shows how much power the PPS generator, the BSSE, and the house load all use. This figure has five parts, which are explained below:

The parts A and C are the parts that charge the battery and give the house electricity from the PV. The PV panels make more power than is needed.

Part E also talks about how the battery runs out of power and how the energy storage system, the battery, sends power to the house. This part of the PV panels is no longer working. The battery runs out of power faster than on B&D parts, as shown in Figure 10, which shows the battery's state of charge. The latter shows how much charge is left in the battery and proves that the proposed system is charging and discharging it.

The B&D parts are what the PV-battery system uses to send electricity to the house and discharge the battery. Because the amount of energy that the PV can produce is less than the amount of energy that is needed. This is why the battery is used to make up for the lack of energy.

Figure 11 shows how powerful the motor pump is and how much more power the PV power has than the electrical loads in the house. The latter confirms that the pump is only working if the difference in power is more than 75 W, which is the pump's rated power.

Figure 12 shows what the four switches are doing. The switch S1 stays closed until the panels have no power (see Fig. 9). The motor that pumps water is powered by switch S4, which is only open when the PV system stops working. The PV-battery combination can meet the energy needs of the house and the motor, so S4 is closed for the rest of the time. The states of switches S2 and S3 show that it is not possible to charge and discharge the battery at the same time. It can either be charged with S2 closed and S3 open or discharged with S3 closed and S2 open.

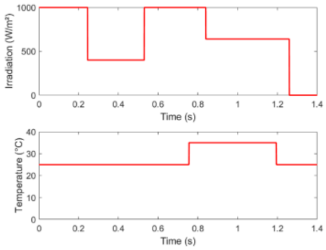

Figure 6: Temperature and Solar irradiation.

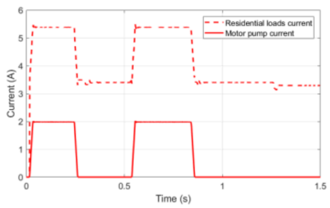

Figure 7: Currents of the loads and the motor pump.

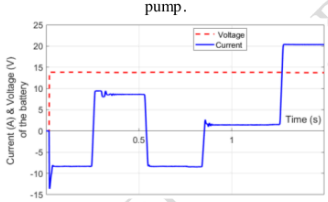

Figure 8: Current and voltage of the battery.

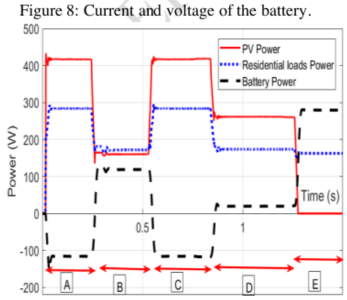

Figure 9: PV generator, the battery and the house load power.

Table 4: Numerical values of the switch status

Switch	A	B	C	D	E
S1	1	1	1	1	0
S2	1	0	1	0	0
S3	0	1	0	1	1
S4	1	0	1	0	0

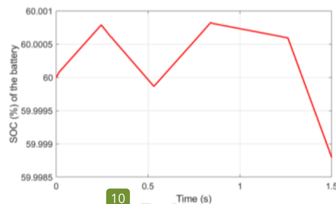

Figure 10: State of charge of the battery

Figure 11: Motor pump difference between the PV power and loads power in the house.

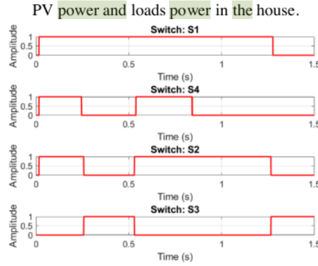

Figure 12: of the Switch's.

Conclusion:-

The purpose of this paper is to improve how a dc grid sends energy between a house's electrical charge, which is its residential load, and a motor pump for farming. A new algorithm for managing energy has been made and put into action in MATLAB-Simulink. The results demonstrated that the proposed technique guarantees energy distribution and irrigation. This means that all farmers can use the PV-Battery system and our proposed method to grow more crops while using less muscle energy. This will help them live a life as people in cities do.

Acknowledgements

The authors warmly acknowledge the contribution of all the faculty researchers from the Departement of Physics, University of Julius Nyerere of Kankan, Republic of Guineaand from the Department of Photovoltaic Energy, University of Labe, Republic of Guinea

References

1. A. Adedeji et al., "Sustainable agriculture in Africa: Plant growth-promoting rhizobacteria (PGPR) to the rescue", *Scientic African*. 2020, vol. 9, pp. e00492.
2. P. Udomkun et al., "Review of solar dryers for agricultural products in Asia and Africa: An innovation landscape approach" *Journal of Environmental Management*, 2020, vol. 268, pp. 110730.
3. C. F. Nicholson et al., "Food security outcomes in agricultural systems models: Case examples and priority information needs" *Agricultural Systems*, 2021, vol. 188, pp. 103030.
4. A. M. LINKE et al., "Environmental stress and agricultural landownership in Africa", *Global Environmental Change*, 2021, vol. 67.
5. H. S. Tossou et al. L'avenir de l'agriculture en guinée: 2030-2063 Étude de cas : Défis et Opportunités pour les projets financés par le FIDA, Étude réalisée en 2020 et publiée en 2021.: https://sites.google.com/view/fidafrique-ifadafrica/ project-management/atelier-r%C3%A9gional-2020/jour-2.
6. M. L. DIALLO et al. Premier rapport biennal actualise de la République de guinée bur1, août 2024, https://unfccc.int/sites/default/files/resource/Premier%20rapport%20biennal%20actualis%C3%A9%20de%20la%20Guin%C3%A9e_Version_Finale%20du%2026082024%20avec%20Branding%20PDF.pdf
7. Politique Nationale de Développement Agricole, Décembre 2017, https://faolex.fao.org/docs/pdf/Gui186295.pdf
8. B. J. Middendorf et al., "Smallholder farmer perceptions about the impact of COVID-19 on agriculture and livelihoods in Senegal", *Agricultural Systems*, 2021, vol. 190, pp. 103108.
9. G. Reed and G. M. Hickey., "Contrasting innovation networks in smallholder agricultural producer cooperatives: Insights from the Niayes Region of Senegal", *Journal of Co-operative Organization and Management*, 2016, pp. 111.
10. S. Bordat and B. Curnier. Mini-Grid Market Opportunity Assessment: Guinea Conakry, June 2020, https://greenminigrid.afdb.org/sites/default/files/guinea-english-3.pdf
11. I. S. Kourouma. Diagnostic environnemental du secteur agricole dans la préfecture de mandiana, Juin 2018 https://www.academia.edu/40980323/DIAGNOSTIC_ENVIRONNEMENTAL_DU_SECTEUR_AGRICOLE_DANS_LA_PREFECTURE_MANDIANA
12. I. Hathie and C. O. Ba. "L'agriculture familiale a l'épreuve de la sécheresse et de la libéralisation au Sénégal", book, 199-212.
13. A. Merida et al., "The environmental and economic benets of a hybrid hydropower energy recovery and solar energy system (PAT-PV), under varying energy demands in the agricultural sector", *Journal of Cleaner Production*, 2021, vol. 303.

14. I. Brahmia et al., "Smart energy dispatch for networked microgrids systems based on distributed control within a hierarchy optimization", *IFAC-Papers OnLine*, 2020, vol. 53, pp. 1299913004.
15. Y. Shang et al., "Stochastic dispatch of energy storage in microgrids: An augmented reinforcement learning approach", *Applied Energy*, 2020, vol. 261, pp. 114423..
16. S. Leonori et al., "Microgrid Energy Management Systems Design by Computational Intelligence Techniques", *Applied Energy*, 2020, vol. 277, pp. 115524.
17. S. Sinha and P. Bajpai, "Power management of hybrid energy storage system in a standalone DC microgrid", *Journal of Energy Storage*, 2020, vol. 30, pp. 101523.
18. F. Tooryan et al., "Optimization and energy management of distributed energy resources for a hybrid residential microgrid", *Journal of Energy Storage*, 2020, vol. 30, pp. 101556.
19. E. C. Nnaji et al., "Modelling and management of smart microgrid for rural electrication in sub-saharan Africa: The case of Nigeria", *Electricity Journal*, 2019, vol. 32.
20. T. Adefarati et al., "Optimal energy management of a PV-WTG-BSS-DG microgrid system", *Energy*, 2021, vol. 217, pp. 119358.
21. W. C. Clarke et al., "Control of an isolated microgrid using hierarchical economic model predictive control", *Applied Energy*, 2020, vol. 280, pp. 15960.
22. M. Sechilariu et al., "DC microgrid power ow optimization by multi-layer supervision control. Design and experimental validation", *Energy Conversion and Management*, 2014, vol. 82, pp. 110.
23. F. Zaouche et al., "Supervision and control strategy for photovoltaic generators with battery storage State of Charge", *International Journal of Hydrogen Energy*, 2017, pp. 120.
24. LIN. Yang, "Supervisory long-term prediction of state of available power for lithium-ion batteries in electric vehicles", *Applied Energy*, 2020, vol. 257, pp. 114006.
25. El. M. Ndiaye et al., "Intelligent Control of a Photovoltaic Generator for Charging and Discharging Battery Using Adaptive Neuro-Fuzzy Inference System", *International Journal of Photoenergy*, 2020, Vol.2020.
26. M. Traore et al., "Supervision of a PV system with storage connected to the power line and design of a battery protection system", *Wireless Networks*, 2018.
27. C. T. Wade, "Physical Characterization of the Koular Valley in Central West Senegal with a View to its Hydro-Agricultural Development", *Journal of Hydrogeology & Hydrologic Engineering*, 2020, vol. 9, pp. 1000189.
28. N. Ghorbani et al., "Optimizing a hybrid wind-PV-battery system using GA-PSO and MOPSO for reducing cost and increasing reliability", *Energy*, 2018, vol. 154, pp. 581591.
29. D. MAZZEO et al., "Energy reliability-constrained method for the multi-objective optimization of a photovoltaic-wind hybrid system with battery storage", *Energy*, 2018, vol. 156, pp. 688708.
30. E. A. Ebrahim, "A general software package for modelling a contact-less electric-vehicles battery-charging public-station fed from on-grid photo-voltaic array", *Journal of Electrical Systems and Information Technology*, 2018, vol. 5, pp. 271286.
31. P. N. R. Solomon and T. Tadesse, "A Review on Solar Photovoltaic Powered Water Pumping System for o-Grid Rural Areas for Domestic use and Irrigation Purpose", *International Journal Of Engineering Research & Technology*, 2021, vol. 10, pp. 258269.

OPTIMAL ENERGY MANAGEMENT STRATEGY OF DC MICRO-GRID FOR MODERN AGRICULTURE: CASE OF MANDIANA PREFECTURE, REPUBLIC OF GUINEA

ORIGINALITY REPORT

13%	10%	8%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.mdpi.com Internet Source	1%
2	"Smart Energy Empowerment in Smart and Resilient Cities", Springer Science and Business Media LLC, 2020 Publication	1%
3	mafiadoc.com Internet Source	1%
4	coek.info Internet Source	1%
5	Fatemeh Tooryan, Hamid HassanzadehFard, Edward R. Collins, Shuangshuang Jin, Bahram Ramezani. "Smart Integration of Renewable Energy Resources, Electrical, and Thermal Energy Storage in Microgrid Applications", Energy, 2020 Publication	1%
6	Submitted to University of Northumbria at Newcastle Student Paper	1%
7	www.researchgate.net Internet Source	1%
8	medium.com Internet Source	1%
9	Submitted to University of Queensland Student Paper	<1%

10	Torreglosa, J.P., P. García, L.M. Fernández, and F. Jurado. "Hierarchical energy management system for stand-alone hybrid system based on generation costs and cascade control", Energy Conversion and Management, 2014. Publication	<1 %
11	www.journalijar.com Internet Source	<1 %
12	Submitted to Indian Institute of Technology, Madras Student Paper	<1 %
13	pretorianews.co.za Internet Source	<1 %
14	ebin.pub Internet Source	<1 %
15	pure.strath.ac.uk Internet Source	<1 %
16	"Demand Response Application in Smart Grids", Springer Science and Business Media LLC, 2020 Publication	<1 %
17	Elbakush, E., A. M. Sharaf, and I. H. Altas. "A novel Green Plug Filter Compensation scheme for electric vehicle DC drive", 2011 International Symposium on Innovations in Intelligent Systems and Applications, 2011. Publication	<1 %
18	journals.stmjournals.com Internet Source	<1 %
19	Haibo Xiao, Yaonan Wang, Di Xiao, Yougui Zhou. "Distributed computing based on AI algorithms in battery early warning and SoH prediction of the intelligent connected	<1 %

vehicles", Neural Computing and Applications, 2020
Publication

20	Narges Ghorbani, Alibakhsh Kasaeian, Ashkan Toopshekan, Leyli Bahrami, Amin Maghami. "Optimizing a Hybrid Wind-PV-Battery System Using GA-PSO and MOPSO for Reducing Cost and Increasing Reliability", Energy, 2017 Publication	<1 %
21	assets-eu.researchsquare.com Internet Source	<1 %
22	etd.cput.ac.za Internet Source	<1 %
23	ifatwww.et.uni-magdeburg.de Internet Source	<1 %
24	ijpeds.iaescore.com Internet Source	<1 %
25	kitakyu.repo.nii.ac.jp Internet Source	<1 %
26	mts.intechopen.com Internet Source	<1 %
27	repo.omikk.bme.hu Internet Source	<1 %
28	sustainenvironres.biomedcentral.com Internet Source	<1 %
29	www.frontiersin.org Internet Source	<1 %
30	"Advances in Green Energies and Materials Technology", Springer Science and Business Media LLC, 2021 Publication	<1 %

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		