Scientific Research Publishing

Smart Grid and Renewable Energy, 2025, 16(1), 1-12
https://www.scirp.org/journal/sgre
ISSN Online: 2151-4844
ISSN Print: 2151-481X

A Review of Research Activities for the Perspective of a Smart Electricity Grid in Burkina Faso

Brice Junior Carmel Wendenda Ilboudo[1], Ollé Michel Kam[2,3], Raguilignaba Sam[1,2]

[1]Laboratoire de Matériaux, d'Heliophysique et Environnement (LaMHE), Département de Physique, Université Nazi BONI, Bobo-Dioulasso, Burkina Faso
[2]Laboratoire de Matériaux et Environnement (LAME), Département de Physique, Université Joseph KI ZERBO, Ouagadougou, Burkina Faso
[3]Science du Numérique, Université Virtuelle du Burkina Faso (UV-BF), Ouagadougou, Burkina Faso
Email: ilboudobricejunior@yahoo.fr

How to cite this paper: Ilboudo, B.J.C.W., Kam, O.M. and Sam, R. (2025) A Review of Research Activities for the Perspective of a Smart Electricity Grid in Burkina Faso. *Smart Grid and Renewable Energy*, **16**, 1-12.
https://doi.org/10.4236/sgre.2025.161001

Received: December 8, 2024
Accepted: January 23, 2025
Published: January 26, 2025

Abstract

This review explores the research activities surrounding the development and integration of smart electricity grids in Burkina Faso, a landlocked and arid territory in West Africa and one of the poorest countries in the world with significant energy challenges. It examines the current state of energy infrastructure in Burkina Faso, focusing on the integration of renewable energy sources, particularly solar photovoltaics. It highlights the role of smart grid technologies in enabling the efficient integration of renewable energy, improving grid stability and facilitating rural electrification. Additionally, the review addresses key challenges such as inadequate infrastructure, regulatory gaps and financial constraints that hinder the deployment of smart grids in the country. By analysing existing research and ongoing projects, this paper provides a comprehensive overview of the opportunities and barriers to implementing a smart electricity grid in Burkina Faso and offers recommendations for future development and policy frameworks.

Keywords

Smart Grid, Smart Building, Decentralised Energy Production, Photovoltaic, Renewable Energy

1. Introduction

Burkina Faso, a landlocked country in West Africa, faces significant challenges in its electricity sector characterized by limited access [1], frequent outages [2], and high dependency on imported fossil fuels and imported electricity from Ghana and Ivory Coast [2]. The massive development of decentralized photovoltaic productions allows for the supply of energy demands, sustainability, and resilience, particularly in rural territories. This distributed electricity production needs a smart electricity grid for better integration into the national electricity grid [3]. Moreover, smart grids can facilitate greater consumer engagement and empowerment, allowing users to actively manage their energy consumption and contribute to demand response programs.

However, the deployment of smart grid technologies requires substantial investment in ICT infrastructures, smart buildings, and training [4]. Policymakers must develop supportive regulatory frameworks and incentives to encourage the adoption of smart grid solutions. Additionally, public awareness and acceptance of new technologies are essential for successful implementation. Therefore, research activities must support the development and implementation of smart grids by overcoming social, technological, and scientific challenges and then proposing opportunities for an effective smart electricity grid.

This review aims to synthesize existing research efforts, identify gaps and propose strategic directions for future research. It seeks to provide a comprehensive state-of-the-art perspective on how smart grids can be effectively deployed to enhance the country's energy landscape by examining the technological, economic and social dimensions of smart grid implementation in Burkina Faso.

2. State of Burkina Faso's National Power Grid

The national power grid of Burkina Faso is poorly developed, with many problems at several levels. According to the World Bank data, only 19.5% of the population had access to electricity in 2022, with a significant disparity between urban areas (around 60.5%) and rural areas (around 3.4%) [1]. The territory power lines are about 25,663 km with 5691 transformer stations [2]. **Figure 1** indicates that 60% of the electricity consumed will be imported in 2022, which highlights the country's strong dependence on external suppliers. The National Electricity Company of Burkina (SONABEL) only contributes to 28% of the electricity production, while the Independent Electricity Producers (PIE) provide 12% of the electricity production. This imbalance reveals a significant dependence on imports to meet national energy demand.

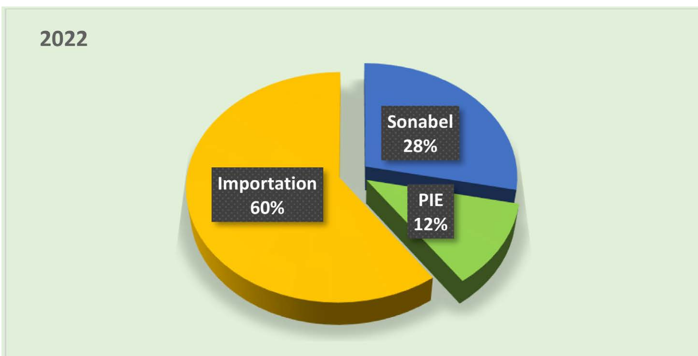

Figure 1. Production and importation of electricity in Burkina Faso in 2022 [2].

The problem of reliability and system quality is mainly due to a mismatch between supply and demand despite the huge amount of energy imported from neighbouring countries. The System Average Interruption Duration Index (SAIDI) is estimated to 77 hours and the System Average Interruption Frequency Index (SAIFI) is estimated to 82 [2] in 2022. Concerning the electricity grid efficiency, the total technical losses from production to consumption are estimated at 12.9% of the total production with a long power line from the production sites to urban consumers. However, many projects are being undertaken to upgrade the rural electrification [5]. These projects mostly revolve around the photovoltaic energy due to the country's geographical location. It offers significant solar potential, with over 2000 kWh/m^2/year of sunlight, making it ideal for photovoltaic (PV) deployment [6]. For example, the YELEEN project, launched in March 2023, is subdivided into two parts, namely rural electrification, the development of photovoltaic power plants and the strengthening of the national electricity system. It aims to increase access to electricity by renewable energy production systems. The objectives include the production of 100 MW of solar energy, the construction of mini-grids for rural areas and the promotion of self-production of solar energy. The implementation is done through public-private partnerships and investments in solar infrastructure. The means deployed include the creation of photovoltaic plants, energy storage installations and technologies to modernize electricity networks. The Zagtouli photovoltaic plant is another of the largest solar installation projects in West Africa. This 33 MW plant aims to enhance Burkina Faso's electricity power supply while reducing its dependence on energy importations. The deployed project includes approximately 130,000 solar panels connected to the national grid with a capacity to provide energy to 660,000 people. Additionally, a lot of private projects and initiatives have been undertaken to install solar power systems. These examples prove that a lot of decentralised solar production systems are deployed in Burkina Faso territory, which is a good way to implement smart grids.

From the policy point of view, the creation of institutions like the National Agency for Renewable Energies and Energy Efficiency (ANEREE) in 2016 and the Burkinabe Rural Electrification Agency (ABER) in 2017 demonstrates governmental commitment to renewable energy integration and rural electrification. This was accompanied by numerous projects to diversify the energy mix through the massive introduction of photovoltaic energy production [7]-[10]. Furthermore, several policies such as "The Law N˚014-2017/AN concerning general regulations of energy sector" [11] and "The decree N˚2019-0902 /PRES/PM/ME/MINEFID/MCIA" [12] were adopted as a first step for smart home by allowing a two-way exchange of electrical flow through the injection of consumers' surplus energy production from photovoltaic production. They establish a legal framework for the integration of renewable energies and the management of energy surplus via self-producers. These texts facilitate independent producers' access to the network, encourage the diversification of energy sources, and promote the digitalization and automation of the electrical system. These texts are essential for the establishment of smart networks, which require an adapted legal infrastructure to optimize production and distribution. Indeed, this law N˚014-2017/AN regulates the electricity sector in Burkina Faso. It aims to regulate the production, transport, distribution and marketing of electrical energy with particular emphasis on the promotion of renewable energies. This law also defines the roles and responsibilities of stakeholders in the energy sector, the conditions of access to the electricity grid, and the rules for pricing and quality of service. The decree N˚2019-0902/PRES/PM/ME/MINEFID/MCIA focuses also on the terms of access for self-producers of renewable energies to the electricity network of Burkina Faso and establishes the conditions for the purchase of excess energy by the national electricity company SONABEL. This decree encourages self-production by allowing individual producers to sell their surplus energy under some technical and contractual conditions. It aims to promote renewable energies while regulating interactions with the existing electricity network, which needs to be more intelligent.

3. Smart Grid and the Burkina's Local Network

The concept of intelligent electrical grids began in the 20th century due to challenges faced by the electrical power industry, such as economic, engineering, and environmental efficiency targets [13]. There is no clear single definition for the concept of smart grid [14]-[17]. Considering all the definitions given, the Smart Grid can be defined as a modernized electrical network that uses advanced communication, information, and management technologies to optimize the production, transport, and distribution of power energy. It is characterised by decentralized power generation sources and bidirectional interaction between the electrical grid and consumptions. It allows better integration of renewable energy sources on the power grid and improves energy efficiency by reducing electricity losses. This can be summed up by the definition given by the International Energy Agency in [18]: "*A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimizing costs and environmental impacts while maximizing system reliability, resilience and stability.*"

The following diagram in **Figure 2** illustrates the evolution of electrical infrastructure and associated communication systems from the past to the future. In the past, the network focused on unidirectional distribution of electricity from power plants to consumers via substations. Actually, the network includes more automation with control centers and two-way connections. In the future, the smart grid will integrate renewable energy sources, energy storage, and consumers who can also become producers (prosumers).

The implementation of an effective smart grid requires that the transmission, the distribution and the demand-side are smart which includes a varied number

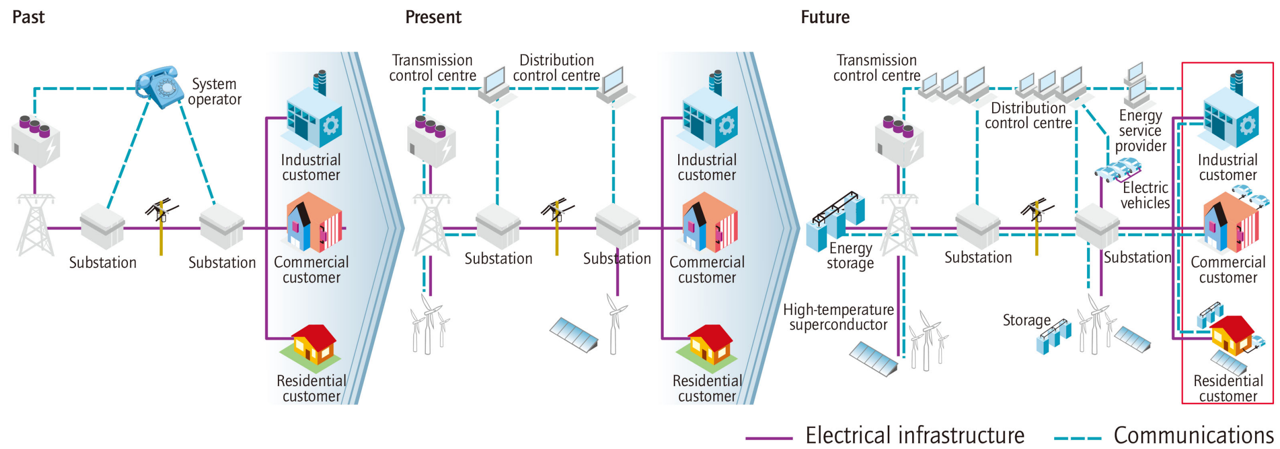

Figure 2. Evolution of the electrical system grid [18].

of interconnected components that work together to improve the efficiency, reliability and sustainability of the system [19]. This means that information and communication technologies, sensing, measurements, control and automation technologies, power electronics and energy storage are smarter. These elements gather all technology areas explored by the smart grid concept [18] as follows:

- Wide-area monitoring and control;
- Information and communication technology integration;
- Renewable and distributed power generation integration;
- Transmission enhancement;
- Distribution grid management;
- Advanced metering infrastructure;
- Electric vehicle charging infrastructure;
- Customer-side systems;
- etc.

This ideal smart power grid characteristics compared to Burkina Faso local power grid shows the gap and challenges to reach an effective intelligent electricity grid [2] [20]-[23]. This comparison is summarized in **Table 1**.

Table 1. This ideal smart power grid compared to Burkina Faso local power grid.

Observed aspects	Burkina Faso's Local Grid	Ideal Smart Grid
Infrastructure	Centralized, manual, outdated	Decentralized, automated, modern
Energy Sources	Mostly fossil fuels, limited renewables	High renewable integration, distributed
Transmission/Distribution	High losses, unreliable distribution	Efficient transmission, reliable distribution
Monitoring & Management	Manual monitoring, limited data	Real-time monitoring, big data analytics
Consumer Interaction	Passive consumers, fixed pricing	Active prosumers, dynamic pricing
Reliability & Resilience	Frequent outages, slow recovery	Self-healing, high reliability
Cybersecurity & Privacy	Minimal concerns	Advanced cybersecurity, privacy protection

The progress toward smart grid implementation in Burkina Faso can be evaluated across many dimensions as renewable energy integration, smart metering, grid automation, transmission and distribution loss reduction and energy storage/demand response. The estimated percentages reflect the current state of implementation in each of these areas based on available data and reports in 2022. The renewable energy integration progress is estimated to 10% - 15% based on the total installed renewable capacity to overall energy generation capacity [24] [25]. The smart metering is estimated to 5% - 10% based on pilot programs launched in cities like Ouagadougou where the number of deployed smart meters is a low fraction of the total number of electricity consumers [26] [27]. The grid automation and monitoring are less than 5% because of the lack of automation technologies and minimal use of Supervisory Control and Data Acquisition (SCADA) or similar systems. The transmission and distribution losses are about 5% compared to the international best practices [28] with unidirectional power transit. Energy storage and demand response mechanisms are virtually absent. The country has not yet implemented large-scale storage solutions and demand-side management. The estimated progress can be set to 1% - 2% [27] [29].

This low rate of smart grid achievement is numerous. The lack of clear regulations and policies which constitute the launching pad for the implementation of smart grids [30] or the lack of substantial state funds allocated to the energy sector for smart grid pilot projects and modernization of power grid installations [18]. All these challenges must also be addressed by research activities.

4. Smart Grid Research Activities in Burkina Faso Context

Research activities must support the development and implementation of smart grids and overcome challenges and opportunities for an effective smart electricity grid. In this paper, researches will be conducted using comprehensive searches in databases such as IEEE Xplore, ScienceDirect, Google Scholar and local repositories, utilizing primary keywords like “smart grid”, “electricity grid”, “renewable energy integration”, “photovoltaics”, “solar energy”, “smart home” and “smart building” combined with “Burkina Faso”, as well as secondary terms such as “decentralized energy systems” and “energy policy” while applying Boolean operators and truncation where necessary. These keywords are applied to research papers published between 2010 and 2024. This period is relevant for the smart grids, the renewable energy or the electricity grid modernization in Burkina Faso and great energy policy reforms engaged in the country. Other criteria considered are papers from peer-reviewed journals, conference papers, and government reports written in English or French. Furthermore, studies unrelated to “Burkina Faso” keyword are not considered in order to focus only on research related to Burkina Faso context.

This research activity exploration shows that the smart grid topic is discussed more and concerns many subjects, as shown in [31]. However, these smart grid research topics applied to Burkina Faso context are oriented on specific domains based on standalone and rural contexts. It concerns the integration of renewable energies combined or not with storage technologies, especially solar photovoltaic, due to the very low rate of electrification in rural areas [32]-[34]. The study in [32] was conducted in 105 villages with a sample of 6,300 consumers. It aimed to identify socio-economic, demographic and geographic factors influencing the choice of solar PV systems or not. It shows that 54% of the surveyed sample use solar systems. 54% of the sample are consumers of large family sizes with entrepreneurial and manufacturing activities, led by young males with high education levels, financial literacy, and access to microfinance. These findings provide insights into implementing smart grid systems in Burkina Faso by leveraging the existing trends and barriers in rural solar PV adoption. It is possible to proceed with targeted motivation by providing micro-credit system, promoting the entrepreneurial activities, enhance campaigns of education and training on energy conservation and the long-term benefits of solar PV systems. This can be summarized as the demand-side integration. Then it can allow the renewable energy integration through distributed solar network by developing decentralized microgrids powered by solar PV with the possibility to add storage systems. [33] also explores the techno-economic feasibility of integrating solar PV systems with energy storage solutions. The storage comparison is made on Pumped hydro-storage (PHS) and lithium-ion batteries, considering both off-grid rural and grid-connected urban system. This comparison is based on the costs, especially the net present cost (NPC) and the cost of energy (COE). Off-grid rural systems show the optimal configuration because they are more cost-effective even when new reservoirs are required for PHS. For grid-connected urban systems, the grid-connected PV systems with PHS are more cost-effective, and it has been shown that adding storage reduces the NPC by 8% compared to a grid-only solution. The renewable fraction of energy supplied increases to more than 88% when PV+PHS is used on grid-connected urban systems. However, the capital costs of PV and storage systems heavily influence the overall NPC and COE. This study lays the foundation for the implementation feasibility of PV systems with storage connected or not to the grid, which is part of the all-smart grid system through the integration of decentralized generation and storage systems.

Another smart grid research topic applied to Burkina Faso context is the energy management. Some researches use consumption trends to manage energy well, prevent outages, and establish appropriate demand-response programs [26] [27] [35]. Other studies are based on the introduction of Advanced Metering Infrastructures (AMI) to improve the reliability of the local grid especially on losses and outages [27]. In fact, [35] aimed to identify the key drivers of electricity consumption in urban consumers in Ouagadougou. The survey of 387 consumers and their electricity consumption based on their bills and the combined models used for the study show that integrating household socio-economic factors and appliance usage explains 70.2% and 70.5% of the variance in residential electricity consumption. The appliance ownership and the usage have nearly equal impacts on the consumption, contrary to some previous studies. These findings provide a roadmap to design and implement specific Demand-side management or adequate Home Energy Management Systems (HEMS) that encourage the use of energy-saving appliances and establish load shifting strategies targeting high-energy devices. It can also help to develop well adapted policies that encourage energy conservation. Also, it can help the utilities through their pattern to optimize supply, forecast the demand and anticipate the impact of urbanization and economic growth on electricity grid. This study shows the interest in integrating smart meter and internet of things to have real-time data to optimize and better predict electricity consumption. [26] research activities present the "*Africit-e*" project, a pilot study in Ouagadougou that leverages smart grid technology to enhance electricity reliability. The project focuses on integrating smart meters and digital tools in the low-voltage network to address challenges such as frequent outages, grid overloads, and customer dissatisfaction. Approximately 500 smart meters were installed in "Azimo Ouaga 2000" and these meters collect real-time data on load curves and voltage profiles for grid modelling and management. A Meter Data Management System (MDMS) was developed to forecast low-voltage network load profiles and identify potential overloads. This system enables targeted demand-response programs to reduce outages caused by congestion. Customer was also involved with an App installed on their smart phones, allowing them to monitor daily electricity usage, estimate bills, and access energy-saving tips. This remote meter reading reduces operational costs and eliminates the need for utility employees to make in-person visits. The project created a digital photovoltaic (PV) hosting capacity map, identifying optimal points for PV connections without costly grid reinforcements. This project improved the reliability of the grid and the cost efficiency. This study explores three smart grid points. The first point is scaling and replicability, which is demonstrated by demonstrating the feasibility of deploying smart meters in low-voltage networks and the viability of similar projects at a national or regional scale through a cost-benefit analysis. The second point is demand-side management, with programs that offer a model for managing peak loads and preventing outages. The third point is the integration of renewable energy with the PV hosting capacity map and the advanced grid analytics that optimize the position of renewables without huge investment. The "*Africit-e*" project shows how smart metering infrastructure can improve electricity reliability, operational efficiency and customer experience in Burkina Faso. Its replicability and cost-effectiveness make it a valuable model. [27] considers the smart grid through demand response strategies as a solution to the challenges faced by the local grid. Their approach is based on smart meters to enable remote control of the subscribed power of consumers and demand response programs to reduce the maximum power available to certain customers to protect grid equipment during overload periods. A simulation was conducted using data from several low-voltage feeders in Ouagadougou, assessing the impact of this strategy. First, this method reduced and prevented overloads on low-voltage feeders during peak hours with a minimal impact on consumers. Then, it improved grid stability through voltage level stabilization and reduction of the risk of load shedding. Finally, this method shows scalability potential and can be extended to other urban areas. The relevance of this study for smart grid development in Burkina Faso is that it is adapted to the local context, it can be integrated with other smart grid solutions such as energy storage and renewable energy sources and it relies on remote modifications, reducing the need for in-site interventions which makes it cost-effective. In order to apply these methods well, investments in smart meters are crucial, consumer awareness campaigns are needed, and the training of grid operators and technical staff in smart grid technologies is necessary.

5. Conclusion

Burkina Faso's energy sector faces notable challenges, including limited access to electricity, high dependency on imported energy, and an underdeveloped national grid. The transition to a smart electricity network seems to be a viable solution to these issues by allowing efficient integration of decentralized solar power systems, improving grid resilience, and promoting energy independence. Current projects demonstrate the country's commitment to renewable energy expansion. However, substantial gaps in infrastructure, funding, and regulatory support persist. To successfully make the transition towards a fully functional smart grid, Burkina Faso must prioritize investments in ICT infrastructure, energy storage, and automated grid management systems. Policies encouraging public-private partnerships, along with supportive regulations, are essential to promote innovation and adoption of smart grid technologies. Moreover, public awareness and research initiatives are crucial to overcoming challenges specific to local contexts, thus ensuring sustainable development in the energy sector.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] World Bank Data: Access to Electricity (% of Population)—Burkina Faso. Data. https://worldbank.org

[2] Sonabel: "Les chiffres-clés de la Sonabel 2022". https://www.sonabel.bf/wp-content/uploads/2023/12/Chiffres-cles.pdf

[3] Taha, M.Q. (2020) Advantages and Recent Advances of Smart Energy Grid. *Bulletin of Electrical Engineering and Informatics*, **9**, 1739-1746. https://doi.org/10.11591/eei.v9i5.2358

[4] Bari, A., Jiang, J., Saad, W. and Jaekel, A. (2014) Challenges in the Smart Grid Applications: An Overview. *International Journal of Distributed Sensor Networks*, **10**, Article ID: 974682. https://doi.org/10.1155/2014/974682

[5] Ministère des Mines et de l'Energie (2013) Politique sectorielle de l'energie 2014-2025. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjk0ZysmY-KAx-

UvU0EAHQwgGp8QFnoECBYQAQ&url=https%3A%2F%2Feira.energychar-ter.org%2Fcomponent%2Fattachments%2Fattach-ments.html%3Fid%3D1954%26task%3Ddownload&usg=AOvVaw3vIIx_EUR-MiWGI5Cx5YUFS&opi=89978449

[6] Plan Solaire Burkina Faso (2019) Projet Yeleen-Composante Ouaga nord-ouest et ligne 90 kV Cadrage et étude de faisabilité de centrales solaires photo-voltaïques. Rapport d'étude d'impact environnemental et social-version finale Juillet. https://esa.afdb.org/sites/default/files/Plan_so-laire_BF_EIES_Ouaga%20NO_ligne%2090kv_VF_20190724.pdf

[7] Projet de construction de centrales photovoltaïques avec stockage (4560 Ah) dans les CMA. https://www.energie-mines.gov.bf/le-ministere/les-structures/de-tails?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontrol-ler%5D=News&tx_news_pi1%5Bnews%5D=75&cHash=596599f1f2bf57916395ac0142de1bae

[8] Projet d'électrification de 300 localités rurales par système solaire photovoltaïque. https://www.energie-mines.gov.bf/le-ministere/les-structures/de-tails?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontrol-ler%5D=News&tx_news_pi1%5Bnews%5D=76&cHash=35a81cd64ea88e6d80f0bbab1fa6c6c7

[9] Projet d'installation de systèmes solaires photovoltaïques sur les bâtiments publics. https://www.energie-mines.gov.bf/le-ministere/les-structures/de-tails?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontrol-ler%5D=News&tx_news_pi1%5Bnews%5D=77&cHash=a7061c5a3cf2993d0e2729f66c2f3225

[10] Projet Yeleen de développement de centrales solaires photovoltaïques et de renforcement du système électrique national. https://www.energie-mines.gov.bf/politique-et-strategies/projet-yeleen

[11] Loi n˚014-2017/an portant reglementation generale du secteur de l'energie. https://www.energie-mines.gov.bf/fileadmin/user_upload/stockage/docu-ments/loi_014-2017_portant_reglementation_gle_du_secteur_de_l_electricite.pdf

[12] Decrect_2019-0902_portant_modalite_dacces_autoproducteur. https://www.arse.bf/spip.php?article235

[13] Sautter, J.A., Landis, J. and Dworkin, M.H. (2009) The Energy Trilemma in the Green Mountain State: An Analysis of Vermont's Energy Challenges and Policy Options. *Vermont Journal of Environmental Law*, **10**, 477.

[14] Gharavi, H. and Ghafurian, R. (2011) Smart Grid: The Electric Energy System of the Future [Scanning the Issue]. *Proceedings of the IEEE*, **99**, 917-921. https://doi.org/10.1109/jproc.2011.2124210

[15] European Commission (2006) European SmartGrids Technology Platform: Vision and Strategy for Europe's Electricity. http://ec.europa.eu/research/energy/pdf/smartgrids_en.pdf

[16] Department of Energy and Climate Change UK (2009) Smarter Grids: The Opportunity.

[17] U.S. Department of Energy, Smart Grid System Report (2009, July). https://www.energy.gov/oe/articles/2009-smart-grid-system-report-july-2009

[18] International Energy Agency (2011, April) Technology Roadmap Smart Grids. https://www.isea.org.il/_files/ugd/61a1db_383d499740864f39a6b1cf475fdaa93c.pdf

[19] Ekanayake, J., Liyanage, K., Wu, J.Z., Yokoyama, A. and Jen-Kins, N. (2012) Smart Grid Technology and Applications. John Wiley & Sons Ltd.

[20] Moner-Girona, M., Bódis, K., Huld, T., Kougias, I. and Szabó, S. (2016) Universal Access to Electricity in Burkina Faso: Scaling-Up Renewable Energy Technologies. *Environmental Research Letters*, **11**, Article ID: 084010. https://doi.org/10.1088/1748-9326/11/8/084010

[21] Jiang, Z., Li, F., Qiao, W., Sun, H., Wan, H., Wang, J., *et al.* (2009) A Vision of Smart Transmission Grids. 2009 *IEEE Power & Energy Society General Meeting*, Calgary, 26-30 July 2009, 1-10. https://doi.org/10.1109/pes.2009.5275431

[22] Kazmi, S.A.A., Shahzad, M.K., Khan, A.Z. and Shin, D.R. (2017) Smart Distribution Networks: A Review of Modern Distribution Concepts from a Planning Perspective. *Energies*, **10**, Article No. 501. https://doi.org/10.3390/en10040501

[23] Societe Nationale d'Electricite du Burkina (Sonabel): Rapport d'activité 2022. https://www.sonabel.bf/wp-content/uploads/2024/02/Rapport-dActivites-2022-avec-compression.pdf

[24] Ministère des Mines et de l'Energie: Plan d'Action National des Energies Re-nouvelables (PANER) Période [2015-2020/2030]. https://www.se4all-africa.org/fileadmin/uploads/se4all/Documents/Country_PANER/Burkina_Faso_Plan_d_Actions_National_pour_les_Energies_Renouvelables.pdf

[25] World Bank (2021) Burkina Faso-Solar Energy and Access Project. https://documents1.worldbank.org/curated/en/988101624586517351/pdf/Burkina-Faso-Solar-Energy-and-Access-Project.pdf

[26] Bollinger, L., Amoroso, R., Richaud, L., Clémence, M., Mouchel, Y., Siarras, S., *et al.* (2021) Modelling and Control of the Low Voltage Network with Smart-Meters to Improve the Reliability of Supply in Burkina Faso, the Africit-E Project. *IET Conference Proceedings*, **2021**, 2173-2177. https://doi.org/10.1049/icp.2021.1544

[27] Grosjean, B., Lassauce, A., Richaud, L., Bayanma, C., Mouchel, Y., Siarras, S., *et al.* (2023) Demand Response Using Remote Modification of Smart-Meters' Subscribed Power to Protect Low-Voltage Feeders in Ouagadougou, Burkina Faso. *IET Conference Proceedings*, **2023**, 3645-3649. https://doi.org/10.1049/icp.2023.0782

[28] IEC—International Electrotechnical Commission: Transmission and Distribution. https://www.iec.ch/system/files/2024-05/2024_iec_transmission_a4_en_lr.pdf

[29] Ministere de L'energie: Stratégie dans le domaine de l'énergie 2019-2023. https://energie.bf/wp-content/uploads/2019/06/Stratégie_Secteur-énergie.pdf

[30] Société Nationale D'Électricité du Burkina (Sonabel). Grille tarifaire applicable à partir du 1er octobre 2023. https://www.sonabel.bf/wp-content/uploads/2023/12/Grille-Tarifaire.pdf

[31] Tuballa, M.L. and Abundo, M.L. (2016) A Review of the Development of Smart Grid Technologies. *Renewable and Sustainable Energy Reviews*, **59**, 710-725. https://doi.org/10.1016/j.rser.2016.01.011

[32] Tinta, A.A., Sylla, A.Y. and Lankouande, E. (2023) Solar PV Adoption in Rural Burkina Faso. *Energy*, **278**, Article ID: 127762. https://doi.org/10.1016/j.energy.2023.127762

[33] Abid, H., Thakur, J., Khatiwada, D. and Bauner, D. (2021) Energy Storage Integration with Solar PV for Increased Electricity Access: A Case Study of Burkina Faso. *Energy*, **230**, Article ID: 120656. https://doi.org/10.1016/j.energy.2021.120656

[34] Palm, S.F., Waita, S., Nyangonda, T. and Chebak, A. (2022). Performance Study of a

Grid Connected Solar PV System in Zagtouli, Burkina Faso. 2022 *IEEE PES/IAS PowerAfrica*, Kigali, 22-26 August 2022, 1-5. https://doi.org/10.1109/powerafrica53997.2022.9905290

[35] Tete, K.H.S., Soro, Y.M. and Sidibé, S.S. (2023). Trends in the Use of Domestic Appliances in Urban Residential Households in Burkina Faso: Results from a Residential Electricity Consumption Survey. 2023 11*th International Conference on Smart Grid* (*icSmartGrid*), Paris, 4-7 June 2023, 1-6. https://doi.org/10.1109/icsmartgrid58556.2023.10170921