



A conceptual framework for optimizing solar power plant development and financing in emerging economies

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Abstract

The growing energy demands and environmental challenges in emerging economies necessitate the adoption of sustainable energy solutions. With its abundant availability and declining costs, solar power offers a promising alternative to traditional energy sources. This paper explores a conceptual framework to optimize solar power plant development and financing in these regions. It highlights the role of technological advancements, innovative infrastructure designs, and scalable solutions in enhancing project viability. The discussion also emphasizes the importance of policy and regulatory frameworks in incentivizing solar energy investments, addressing challenges, and aligning national goals with global energy objectives. Furthermore, financial models, including innovative mechanisms and public-private partnerships, are examined for their potential to attract stakeholders and mitigate risks. Practical recommendations for policymakers, investors, and developers underscore the need for a collaborative and multi-faceted approach to realize the transformative potential of solar energy. By addressing these critical aspects, this paper aims to contribute to the advancement of solar energy adoption and the broader sustainability agenda in emerging economies.

Keywords: Solar Energy; Emerging Economies; Renewable Energy Financing; Policy Frameworks; Public-Private Partnerships; Infrastructure Optimization

1. Introduction

Solar power stands as a transformative force in the global energy sector, offering a sustainable solution to meet growing electricity demands while addressing environmental concerns. In emerging economies, the significance of solar energy is magnified due to its potential to bridge the gap between energy deficits and developmental aspirations (Cantarero, 2020). Many of these nations face challenges such as unreliable power supply, dependency on fossil fuels, and the associated economic and environmental costs. Solar power, with its abundance and renewable nature, provides an opportunity to diversify energy sources, reduce greenhouse gas emissions, and enhance energy security (Strielkowski, Cívín, Tarkhanova, Tvaronavičienė, & Petrenko, 2021).

Emerging economies are characterized by rapid population growth and industrial expansion, which fuel increased energy demands. Unfortunately, traditional energy systems in these regions often lack the capacity to meet such demands effectively, leading to frequent power shortages and reliance on costly imports of fossil fuels (Shahsavari & Akbari, 2018). Solar power offers a decentralized and scalable energy solution, allowing regions with limited access to grid infrastructure to benefit from reliable electricity. Moreover, advances in photovoltaic technology have made solar

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power generation more cost-competitive, further enhancing its appeal as a sustainable energy source (Mueller et al., 2016).

Despite these advantages, developing and financing solar power plants in emerging economies face several challenges. One prominent obstacle is the high upfront cost associated with establishing solar facilities. While operational costs are relatively low, the initial investment can deter governments and private investors, especially in regions with limited financial resources (Oyedepo, 2014). Another challenge lies in the lack of supportive policies and regulatory frameworks, which are critical for creating a conducive environment for investment. Furthermore, inadequate technical expertise, infrastructure, and the intermittent nature of solar energy pose additional hurdles (Nandal, Kumar, & Singh, 2019).

On the other hand, these challenges present unique opportunities. Governments and international organizations can collaborate to develop financial mechanisms and incentives that lower the barriers to entry for investors. Technological innovations, such as energy storage systems and smart grid integration, can mitigate issues related to intermittency and enhance the efficiency of solar power plants (Tan et al., 2021). Additionally, the increasing global emphasis on renewable energy opens avenues for emerging economies to attract foreign direct investment and forge partnerships with stakeholders committed to sustainable development.

This paper aims to develop a conceptual framework for optimizing the development and financing of solar power plants in emerging economies. The framework seeks to address the multifaceted challenges faced by stakeholders, offering insights into technological innovations, policy initiatives, and financial strategies that can accelerate solar energy adoption. By focusing on practical and actionable solutions, this framework aspires to empower policymakers, investors, and developers to harness the full potential of solar energy while promoting sustainable economic growth.

The scope of the framework encompasses key dimensions critical to the successful deployment of solar projects. These include technological advancements in infrastructure design, policy and regulatory measures, and innovative financial models tailored to the unique needs of emerging economies. In doing so, the framework highlights the current state of solar power development and identifies pathways for overcoming existing barriers and fostering long-term growth. Through this approach, the paper contributes to the broader discourse on renewable energy, emphasizing the pivotal role of solar power in shaping a sustainable and equitable energy future for emerging economies.

2. Technological Innovations and Infrastructure Design

2.1. Emerging Technologies in Solar Power Generation

Advancements in solar power generation technologies have been pivotal in making renewable energy more efficient, reliable, and cost-effective. Key developments include the evolution of photovoltaic (PV) systems, concentrated solar power (CSP), and hybrid energy systems (Pandey et al., 2016). Modern PV cells, such as monocrystalline and bifacial modules, offer higher efficiency and improved performance compared to older technologies. These innovations enable the generation of more electricity even in regions with moderate sunlight, making solar power a feasible option for diverse climates (N. M. Kumar et al., 2020). Furthermore, tandem PV cells, which stack multiple layers of materials, have broken efficiency records, paving the way for greater energy output from the same surface area (Akhil et al., 2021).

CSP systems, which use mirrors or lenses to focus sunlight onto a receiver, are another emerging technology transforming the solar landscape. Unlike traditional PV systems, CSP plants can incorporate thermal energy storage, allowing them to produce electricity even during non-sunny periods (K. R. Kumar, Chaitanya, & Kumar, 2021). This capability is particularly advantageous for regions with fluctuating energy demands. Also, hybrid systems combining solar with other renewable energy sources, such as wind or hydro, are gaining traction. These systems balance the intermittency of solar energy by leveraging complementary energy sources, enhancing overall reliability and grid stability (Pathak, Deshpande, & Jadkar, 2017).

2.2. Strategies for Optimizing Plant Design

Effective plant design and seamless integration with existing infrastructure are critical to maximizing the potential of solar power projects. One key strategy is the use of advanced tracking systems, such as single-axis and dual-axis trackers, which align solar panels to follow the sun's movement (Babajide, 2015). These systems can significantly increase energy capture compared to fixed-tilt installations. Additionally, innovative layout designs that minimize shading and optimize land use are essential for improving energy output and cost efficiency (Lechner, 2014).

Another important consideration is the integration of solar power plants into existing power grids. Smart grid technology plays a crucial role in this process, enabling better electricity generation and distribution management. Through real-time data monitoring and predictive analytics, smart grids ensure that solar energy is effectively utilized and balanced with other energy sources (Zhang, Huang, & Bompard, 2018). This is particularly important in regions where grid infrastructure is outdated or underdeveloped. Technologies such as grid-tied inverters and energy storage systems further facilitate this integration, allowing excess energy to be stored and redistributed during periods of high demand (Syed et al., 2020).

Furthermore, floating solar farms are emerging as a solution to land scarcity, particularly in densely populated areas. By utilizing bodies of water such as reservoirs and lakes, floating installations minimize land use conflicts while providing additional benefits, such as reduced water evaporation and improved panel efficiency due to cooling from the water surface. This innovative approach exemplifies how infrastructure design can adapt to specific regional constraints (Sahu, Yadav, & Sudhakar, 2016).

2.3. Importance of Scalability and Durability in Solar Power Projects

Scalability is a fundamental aspect of solar power projects, particularly in emerging economies where energy needs are expected to grow over time. Modular solar systems offer a scalable solution by allowing projects to be expanded incrementally as demand increases (Dobrotkova, Surana, & Audinet, 2018). This approach is particularly advantageous for rural and underserved areas, where small-scale installations can be deployed initially and later upgraded into larger systems as resources become available. The modular nature of these systems also reduces the upfront investment required, making them more accessible to communities and smaller investors.

Durability is equally important in ensuring the long-term success of solar power projects. Harsh environmental conditions, such as high temperatures, humidity, or dust, can significantly impact the performance and lifespan of solar installations (Costa, Diniz, & Kazmerski, 2018). To address these challenges, manufacturers are developing robust materials and coatings that enhance the durability of PV modules. Anti-reflective coatings, for example, improve energy absorption and protect panels from degradation caused by dirt and debris. Similarly, advancements in corrosion-resistant materials extend the lifespan of structural components, reducing maintenance costs and ensuring reliable operation (Ferrari & Cirisano, 2020).

In addition to materials, predictive maintenance technologies are vital in enhancing durability. By using sensors and data analytics, operators can monitor the health of solar installations and identify potential issues before they escalate into costly repairs. This proactive approach minimizes downtime and ensures that the plants operate optimally throughout their lifecycle (Pech, Vrchota, & Bednář, 2021).

3. Policy and Regulatory Frameworks

3.1. Role of Government Policies in Promoting Solar Energy

Government policies play a pivotal role in fostering the adoption of solar energy by creating an enabling environment for stakeholders, including developers, investors, and consumers. Governments can address the barriers to solar energy deployment through well-crafted policies, such as high initial costs, technological limitations, and lack of infrastructure. One of the most effective tools in this regard is the introduction of financial incentives, such as subsidies, tax credits, and grants. These measures lower the financial burden on project developers and make solar energy more accessible to a broader range of investors.

Feed-in tariffs (FITs), for example, have been instrumental in encouraging renewable energy development in numerous countries. FITs guarantee fixed payments to solar power producers for the electricity they generate and supply to the grid, providing a stable revenue stream and reducing investment risks (Ndiritu & Engola, 2020). Similarly, net metering policies allow consumers to sell excess electricity from rooftop systems back to the grid, promoting decentralized energy production and incentivizing residential and commercial users to adopt solar technology (Schelly, Louie, & Pearce, 2017).

Governments also play a crucial role in facilitating the development of supportive infrastructure. Investments in modernizing grid systems, establishing energy storage facilities, and developing transmission networks are essential to accommodate the intermittent nature of solar energy and ensure its efficient distribution. In addition, training programs and capacity-building initiatives for local engineers and technicians help create a skilled workforce capable of supporting the solar energy sector's growth (Shoemaker & Ribeiro, 2018).

3.2. Regulatory Challenges and Solutions for Incentivizing Investment

Despite the potential of solar energy, regulatory barriers often hinder its widespread adoption. One significant challenge is the absence of clear and consistent regulations, which creates uncertainty for investors. Ambiguities in land acquisition processes, permitting procedures, and grid connection protocols can delay project implementation and increase costs. To address this, governments must establish transparent and streamlined regulatory frameworks that reduce administrative bottlenecks and provide clarity to stakeholders.

Another challenge lies in the lack of robust mechanisms to manage the intermittency of solar energy. Regulatory frameworks need to incentivize the integration of energy storage solutions, such as batteries, and support the development of hybrid systems that combine solar with other energy sources. This can be achieved through policies that encourage research and development and subsidies for innovative technologies (Kyriakopoulos & Arabatzis, 2016).

Financing remains a critical barrier, particularly in emerging economies where financial institutions may be reluctant to invest in large-scale renewable energy projects due to perceived risks. Governments can mitigate this by establishing public-private partnerships and green banks that provide low-interest loans, guarantees, and risk-sharing mechanisms (Nasirov, Silva, & Agostini, 2015). Additionally, regulatory bodies can implement carbon pricing schemes, such as carbon taxes or cap-and-trade systems, to make fossil fuels less competitive and shift investment towards cleaner energy sources.

To ensure long-term success, it is essential to include mechanisms for monitoring and evaluating the performance of regulatory policies. Feedback loops incorporating stakeholder input and adapting regulations based on lessons learned can help create a more dynamic and effective regulatory environment (Castillo & Gayme, 2014).

3.3. International Cooperation and Alignment with Global Energy Goals

International cooperation is vital for advancing solar energy adoption in an increasingly interconnected world, particularly in emerging economies. Global initiatives like the Paris Agreement have highlighted the importance of transitioning to renewable energy to mitigate climate change and achieve sustainable development goals. By aligning national policies with these global objectives, countries can access financial and technical support from international organizations and development banks.

One example of effective international collaboration is the establishment of solar-specific alliances, such as the International Solar Alliance (ISA). These platforms bring together countries, private entities, and non-governmental organizations to share knowledge, mobilize resources, and promote joint projects. Such initiatives enable emerging economies to leverage the expertise and funding of more advanced nations, accelerating the deployment of solar energy.

Technology transfer is another critical component of international cooperation. Developed nations can facilitate the adoption of advanced solar technologies in emerging economies by offering affordable licensing agreements, training programs, and technical assistance. Additionally, collaborative research initiatives between institutions from different countries can drive innovation and reduce emerging technologies' costs (Lema & Lema, 2016).

Harmonizing regulatory standards across borders can also enhance the efficiency of solar energy projects. For instance, standardizing equipment specifications and certification processes can simplify procurement and reduce costs for developers operating in multiple markets. Regional energy markets, where countries pool resources and trade renewable energy, can further enhance the viability of solar power by addressing supply and demand imbalances (Boie, Fernandes, Frías, & Klobasa, 2014).

4. Financial Models and Investment Strategies

4.1. Innovative Financing Mechanisms for Solar Projects

Financing remains a significant barrier to the widespread adoption of solar energy, particularly in regions where economic constraints limit access to capital. However, innovative financial mechanisms have emerged to address these challenges and facilitate the deployment of solar power projects (Polzin, 2017). One such mechanism is green bonds, which are fixed-income instruments specifically designed to fund renewable energy projects. Green bonds offer an attractive option for institutional and private investors seeking sustainable investment opportunities. These bonds provide long-term financing at relatively low interest rates by channeling funds from global capital markets, making large-scale solar installations more feasible (Deschryver & De Mariz, 2020).

Another innovative approach is crowdfunding, which leverages contributions from individuals and communities to finance solar initiatives. Platforms dedicated to renewable energy projects allow small-scale investors to participate in funding solar plants, thereby democratizing access to clean energy investments. Crowdfunding is particularly effective for smaller projects, such as community-based solar farms or rooftop systems, which may not attract traditional investors (Vasileiadou, Huijben, & Raven, 2016).

Lease-to-own models have also gained popularity, particularly in residential and commercial markets. Under this arrangement, customers lease solar systems and pay a fixed monthly fee, with the option to purchase the system after a predetermined period (Patel & Nyangena, 2016). This model eliminates the need for substantial upfront costs, making solar technology more accessible to households and small businesses. Similarly, power purchase agreements (PPAs) enable project developers to finance solar installations by entering into long-term contracts with off-takers who agree to buy the generated electricity at a fixed rate. This approach ensures a steady revenue stream for developers while providing off-takers with affordable energy (Umamaheswaran & Rajiv, 2015).

4.2. Risk Mitigation Approaches to Attract Stakeholders

Risk mitigation is essential to attract investors and stakeholders to solar projects, particularly in emerging economies with higher perceived risks. One effective strategy is the use of credit enhancement tools, such as loan guarantees and insurance products, to reduce the financial risk associated with solar investments. Guarantees provided by multilateral development banks and export credit agencies can reassure investors by covering potential losses in the event of default or political instability (Frisari & Stadelmann, 2015).

Currency risk is another major concern for international investors operating in regions with volatile exchange rates. To address this, governments and financial institutions can establish hedging mechanisms or offer currency stabilization funds that protect investors from adverse fluctuations. Similarly, political risk insurance, which safeguards against policy changes or expropriation, can alleviate concerns about regulatory uncertainty.

Technical and operational risks can also be mitigated through rigorous due diligence and robust project planning. Conducting detailed feasibility studies, employing experienced contractors, and adopting best practices in construction and maintenance can minimize delays and cost overruns. Additionally, using advanced monitoring systems to track the performance of solar plants ensures that any issues are identified and addressed promptly, reducing operational disruptions (Smith, Merna, & Jobling, 2014).

A diversified investment portfolio further mitigates risk by spreading exposure across multiple projects and regions. By pooling resources into investment funds dedicated to renewable energy, stakeholders can reduce their vulnerability to individual project failures while benefiting from economies of scale.

4.3. Public-Private Partnerships and Their Impact on Long-Term Viability

Public-private partnerships have proven to be a powerful tool for advancing solar energy projects, particularly in regions with limited government resources. By leveraging private entities' expertise and financial capacity, PPPs enable the development of large-scale solar plants that might otherwise be unattainable. These collaborations often involve cost-sharing arrangements, where the public sector provides land, infrastructure, or subsidies while private entities take on project development and operational responsibilities (Awuku, Bennadji, Muhammad-Sukki, & Sellami, 2021).

One of the key advantages of PPPs is their ability to attract private investment by reducing risks through government involvement. For example, governments can offer long-term concessions or tax incentives to private developers, ensuring stable returns on investment. Additionally, PPPs can facilitate access to international funding by demonstrating a commitment to renewable energy through strong public-sector support (Fleta-Asín & Muñoz, 2021).

The impact of PPPs extends beyond financing; they also contribute to capacity building and knowledge transfer. By partnering with experienced private companies, governments can enhance their technical expertise and develop local industries related to solar energy. Furthermore, PPPs can drive innovation by fostering competition and encouraging private entities to adopt cutting-edge technologies. Transparency and accountability are critical to the success of PPPs. Clear contractual agreements that outline the roles, responsibilities, and risk-sharing arrangements between public and private partners help build trust and ensure project sustainability. Regular monitoring and evaluation mechanisms are also essential to assess the performance of PPP initiatives and make necessary adjustments.

5. Conclusion

Solar energy presents an unparalleled opportunity to address energy challenges in emerging economies, offering a sustainable, affordable, and scalable alternative to fossil fuels. Key findings highlight those technological advancements, such as high-efficiency photovoltaic cells and hybrid energy systems, have significantly enhanced the viability of solar power. Infrastructure design innovations, including tracking systems and smart grid integration, further bolster the reliability and efficiency of solar plants.

Policy frameworks and regulatory measures remain instrumental in accelerating solar energy adoption. Governments are critical in providing incentives, streamlining regulations, and fostering international collaborations. However, regulatory uncertainties and financing barriers persist, underscoring the need for targeted interventions. Financial models, including green bonds, power purchase agreements, and public-private partnerships, have emerged as effective tools to attract investment and mitigate risks. By aligning technological, regulatory, and financial strategies, stakeholders can create an ecosystem conducive to the rapid deployment of solar energy projects.

Governments should prioritize creating a clear and consistent regulatory framework that simplifies land acquisition, permitting, and grid connection processes. Policies must also emphasize the integration of energy storage systems to address intermittency and enhance grid reliability. Financial incentives, such as tax breaks, subsidies, and feed-in tariffs, should be sustained and tailored to local contexts to encourage investment. Additionally, governments must invest in capacity building by training local engineers and technicians and fostering research collaborations to develop region-specific solar technologies.

Private and institutional investors should diversify their portfolios by exploring opportunities in both utility-scale projects and decentralized systems. Collaborative investment mechanisms like renewable energy funds can help spread risks and leverage collective expertise. Investors are also encouraged to engage in due diligence, focusing on projects with robust risk mitigation measures, such as political risk insurance and credit guarantees. By supporting innovative financing models, including crowdfunding platforms and lease-to-own schemes, investors can expand access to solar technology for underserved communities.

Solar project developers should adopt advanced technologies and design strategies that maximize energy output and minimize costs. Integrating tracking systems, hybrid configurations, and floating installations can improve efficiency and adaptability to diverse environments. Collaboration with policymakers and financial institutions is crucial to ensure alignment with regulatory requirements and secure funding. Developers should also emphasize community engagement to foster local acceptance and participation in solar projects.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

- [1] Akhil, S., Akash, S., Pasha, A., Kulkarni, B., Jalalah, M., Alsaiari, M., . . . Balakrishna, R. G. (2021). Review on perovskite silicon tandem solar cells: Status and prospects 2T, 3T and 4T for real world conditions. *Materials & Design*, 211, 110138.
- [2] Awuku, S. A., Bennadji, A., Muhammad-Sukki, F., & Sellami, N. (2021). Promoting the Solar Industry in Ghana through Effective Public-Private Partnership (PPP): Some Lessons from South Africa and Morocco. *Energies*, 15(1), 17.
- [3] Babajide, B. E. (2015). *Modelling of an Efficient Dynamic Smart Solar Photovoltaic Power Grid System*. Balogun Emmanuel Babajide. University of Canberra.
- [4] Boie, I., Fernandes, C., Frías, P., & Klobasa, M. (2014). Efficient strategies for the integration of renewable energy into future energy infrastructures in Europe—An analysis based on transnational modeling and case studies for nine European regions. *Energy Policy*, 67, 170-185.
- [5] Cantarero, M. M. V. (2020). Of renewable energy, energy democracy, and sustainable development: A roadmap to accelerate the energy transition in developing countries. *Energy Research & Social Science*, 70, 101716.

- [6] Castillo, A., & Gayme, D. F. (2014). Grid-scale energy storage applications in renewable energy integration: A survey. *Energy Conversion and Management*, 87, 885-894.
- [7] Costa, S. C., Diniz, A. S. A., & Kazmerski, L. L. (2018). Solar energy dust and soiling R&D progress: Literature review update for 2016. *Renewable and Sustainable Energy Reviews*, 82, 2504-2536.
- [8] Deschryver, P., & De Mariz, F. (2020). What future for the green bond market? How can policymakers, companies, and investors unlock the potential of the green bond market? *Journal of Risk and Financial Management*, 13(3), 61.
- [9] Dobrotkova, Z., Surana, K., & Audinet, P. (2018). The price of solar energy: Comparing competitive auctions for utility-scale solar PV in developing countries. *Energy Policy*, 118, 133-148.
- [10] Ferrari, M., & Cirisano, F. (2020). High transmittance and highly amphiphobic coatings for environmental protection of solar panels. *Advances in Colloid and Interface Science*, 286, 102309.
- [11] Fleta-Asín, J., & Muñoz, F. (2021). Renewable energy public-private partnerships in developing countries: Determinants of private investment. *Sustainable Development*, 29(4), 653-670.
- [12] Frisari, G., & Stadelmann, M. (2015). De-risking concentrated solar power in emerging markets: The role of policies and international finance institutions. *Energy Policy*, 82, 12-22.
- [13] Kumar, K. R., Chaitanya, N. K., & Kumar, N. S. (2021). Solar thermal energy technologies and its applications for process heating and power generation—A review. *Journal of cleaner production*, 282, 125296.
- [14] Kumar, N. M., Chopra, S. S., de Oliveira, A. K. V., Ahmed, H., Vaezi, S., Madukanya, U. E., & Castañón, J. M. (2020). Solar PV module technologies. In *Photovoltaic Solar Energy Conversion* (pp. 51-78): Elsevier.
- [15] Kyriakopoulos, G. L., & Arabatzis, G. (2016). Electrical energy storage systems in electricity generation: Energy policies, innovative technologies, and regulatory regimes. *Renewable and Sustainable Energy Reviews*, 56, 1044-1067.
- [16] Lechner, N. (2014). *Heating, cooling, lighting: Sustainable design methods for architects*: John Wiley & Sons.
- [17] Lema, A., & Lema, R. (2016). Low-carbon innovation and technology transfer in latecomer countries: Insights from solar PV in the clean development mechanism. *Technological Forecasting and Social Change*, 104, 223-236.
- [18] Mueller, A., Orosz, M., Narasimhan, A. K., Kamal, R., Hemond, H. F., & Goswami, Y. (2016). Evolution and feasibility of decentralized concentrating solar thermal power systems for modern energy access in rural areas. *MRS Energy & Sustainability*, 3, E4.
- [19] Nandal, V., Kumar, R., & Singh, S. (2019). Barriers identification and analysis of solar power implementation in Indian thermal power plants: An Interpretative Structural Modeling approach. *Renewable and Sustainable Energy Reviews*, 114, 109330.
- [20] Nasirov, S., Silva, C., & Agostini, C. A. (2015). Investors' perspectives on barriers to the deployment of renewable energy sources in Chile. *Energies*, 8(5), 3794-3814.
- [21] Ndiritu, S. W., & Engola, M. K. (2020). The effectiveness of feed-in-tariff policy in promoting power generation from renewable energy in Kenya. *Renewable Energy*, 161, 593-605.
- [22] Oyedepo, S. O. (2014). Towards achieving energy for sustainable development in Nigeria. *Renewable and Sustainable Energy Reviews*, 34, 255-272.
- [23] Pandey, A. K., Tyagi, V., Jeyraj, A., Selvaraj, L., Rahim, N., & Tyagi, S. (2016). Recent advances in solar photovoltaic systems for emerging trends and advanced applications. *Renewable and Sustainable Energy Reviews*, 53, 859-884.
- [24] Patel, L., & Nyangena, H. (2016). Innovative Distribution Models for Uptake of Sustainable Fuels Findings from the Pilot Stage.
- [25] Pathak, A., Deshpande, K., & Jadkar, S. (2017). Application of Solar Thermal Energy for Medium Temperature Heating in Automobile Industry. Paper presented at the Conference on Science & Engineering for Sustainable Development.
- [26] Pech, M., Vrchota, J., & Bednář, J. (2021). Predictive maintenance and intelligent sensors in smart factory. *Sensors*, 21(4), 1470.

- [27] Polzin, F. (2017). Mobilizing private finance for low-carbon innovation—A systematic review of barriers and solutions. *Renewable and Sustainable Energy Reviews*, 77, 525-535.
- [28] Sahu, A., Yadav, N., & Sudhakar, K. (2016). Floating photovoltaic power plant: A review. *Renewable and Sustainable Energy Reviews*, 66, 815-824.
- [29] Schelly, C., Louie, E. P., & Pearce, J. M. (2017). Examining interconnection and net metering policy for distributed generation in the United States. *Renewable Energy Focus*, 22, 10-19.
- [30] Shahsavari, A., & Akbari, M. (2018). Potential of solar energy in developing countries for reducing energy-related emissions. *Renewable and Sustainable Energy Reviews*, 90, 275-291.
- [31] Shoemaker, M., & Ribeiro, D. (2018). Through the local government lens: Developing the Energy Efficiency Workforce. Paper presented at the American Council for an Energy-Efficient Economy.
- [32] Smith, N. J., Merna, T., & Jobling, P. (2014). *Managing risk in construction projects*: John Wiley & Sons.
- [33] Strielkowski, W., Civiń, L., Tarkhanova, E., Tvaronavičienė, M., & Petrenko, Y. (2021). Renewable energy in the sustainable development of electrical power sector: A review. *Energies*, 14(24), 8240.
- [34] Syed, D., Zainab, A., Ghrayeb, A., Refaat, S. S., Abu-Rub, H., & Bouhali, O. (2020). Smart grid big data analytics: Survey of technologies, techniques, and applications. *IEEE access*, 9, 59564-59585.
- [35] Tan, K. M., Babu, T. S., Ramachandaramurthy, V. K., Kasinathan, P., Solanki, S. G., & Raveendran, S. K. (2021). Empowering smart grid: A comprehensive review of energy storage technology and application with renewable energy integration. *Journal of Energy Storage*, 39, 102591.
- [36] Umamaheswaran, S., & Rajiv, S. (2015). Financing large scale wind and solar projects—A review of emerging experiences in the Indian context. *Renewable and Sustainable Energy Reviews*, 48, 166-177.
- [37] Vasileiadou, E., Huijben, J., & Raven, R. (2016). Three is a crowd? Exploring the potential of crowdfunding for renewable energy in the Netherlands. *Journal of cleaner production*, 128, 142-155.
- [38] Zhang, Y., Huang, T., & Bompard, E. F. (2018). Big data analytics in smart grids: a review. *Energy informatics*, 1(1), 1-24.