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A Comparative Study between SPV (Solar Photovoltaic) Electricity and PKL (Pathor Kuchi Leaf) Electricity

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ABSTRACT

This study presents a comparative analysis between solar photovoltaic (PV) electricity and PKL (Pathor Kuchi Leaf) electricity, focusing on their potential as sustainable energy sources. Solar PV technology, widely adopted across the globe, converts sunlight directly into electricity through semiconductor materials, offering a mature and commercially viable solution. In contrast, PKL electricity is an emerging bio-inspired technology that harnesses the photosynthetic properties of natural leaves or artificial analogs to generate electrical energy. The research evaluates both systems in terms of efficiency, cost-effectiveness, scalability, environmental impact, and applicability in rural and urban contexts. Findings indicate that while solar PV remains superior in terms of efficiency, reliability, and large-scale deployment, PKL electricity demonstrates unique advantages such as low-cost materials, eco-friendliness, and potential for localized energy generation in resource-constrained regions. The study concludes that PKL electricity, though still in its experimental stage, could complement solar PV in achieving sustainable energy goals, particularly in areas where conventional solar infrastructure is economically or technically challenging. This comparative assessment highlights the importance of integrating diverse renewable technologies to meet future energy demands sustainably.

Keywords: Solar Photovoltaic (PV) Electricity, PKL (Photo-Katalytic Leaf) Electricity, Renewable Energy, Sustainable Power Generation, Efficiency Comparison, Cost-effectiveness, Environmental Impact, Rural Electrification, Green Technology, Alternative Energy Sources

I. Introduction

The global demand for sustainable and renewable energy sources has intensified in recent decades due to rising concerns over climate change, depletion of fossil fuels, and environmental degradation[1-3]. Among the various renewable technologies, solar photovoltaic (PV) electricity has emerged as one of the most widely adopted solutions, converting sunlight directly into electrical energy through semiconductor materials[4-5]. Its scalability, reliability, and commercial maturity have made it a cornerstone of modern renewable energy systems.

In parallel, innovative approaches such as PKL (Pathor Kuchi Leaf Leaf) electricity have gained attention as potential alternatives[6]. PKL technology is inspired by the natural process of photosynthesis, utilizing bio-mimetic or natural leaf structures to generate electricity. Unlike conventional PV systems, PKL electricity emphasizes eco-friendly materials, low-cost fabrication, and localized energy generation, making it particularly attractive for rural or resource constrained regions[7-9].

This study aims to conduct a comparative analysis between solar PV and PKL electricity, examining their efficiency, cost, environmental impact, and practical applicability. While solar PV represents a proven and commercially viable technology, PKL electricity remains in its experimental stage, offering unique opportunities for sustainable innovation[10-15]. By evaluating the strengths and limitations of both systems, this research seeks to highlight their roles in advancing renewable energy solutions and contributing to global energy sustainability.

The growing global energy crisis and environmental concerns have intensified the search for renewable and eco-friendly alternatives to fossil fuels. Among the various options, Solar Photovoltaic (SPV) electricity has become one of the most established technologies, converting sunlight directly into electricity through semiconductor materials. Its proven efficiency, scalability, and integration into modern power systems have made SPV a cornerstone of sustainable energy development worldwide[16-19].

In contrast, **PKL (Pathor Kuchi Leaf) electricity** represents a novel, bio-inspired approach that utilizes the natural properties of the *Pathor Kuchi Leaf* (Bryophyllum pinnatum) to generate electrical energy[20-23]. This plant-based technology mimics aspects of photosynthesis and electrochemical reactions, offering a low-cost, biodegradable, and environmentally friendly alternative. Although PKL electricity is still in its experimental stage, it has attracted attention for its potential to provide localized energy solutions, particularly in rural or resource constrained regions[25-26].

This comparative study aims to analyze SPV and PKL electricity in terms of efficiency, cost effectiveness, environmental impact, and scalability[27-28]. By evaluating the strengths and limitations of both systems, the research seeks to highlight their complementary roles in advancing renewable energy technologies. While SPV continues to dominate as a reliable and commercially viable solution, PKL electricity introduces innovative possibilities that could contribute to a diversified and sustainable energy future[29-30].

II. Methodology

To evaluate the relative merits of solar photovoltaic (PV) electricity and PKL (Photo Kuch Leaf) electricity, this study adopts a comparative research design. The methodology integrates both experimental and analytical approaches to ensure a balanced assessment.

IIA. Materials

- **Solar Photovoltaic (SPV) System**
  - Commercially available PV modules (monocrystalline or polycrystalline).
  - Charge controller, inverter, and storage battery.
  - Measuring instruments: digital multimeter, solar irradiance meter, and data logger.

- **PKL (Pathor Kuchi Leaf) System**
  - Fresh *Pathor Kuchi Leaves* (Bryophyllum pinnatum).
  - Electrolyte solution (commonly saltwater or acidic medium).
  - Electrodes (copper and zinc plates).
  - Measuring instruments: digital multimeter, wires, and connectors.

- **Common Laboratory Equipment**
  - Light source (sunlight or artificial lamp for controlled experiments).
  - Stopwatch, thermometer, and calibrated scales.

IIB. Methods

1 Prepare SPV Setup

Setup:

Assemble the solar photovoltaic system for testing.

- Connect PV module to charge controller and inverter
- Attach battery for storage
- Use multimeter to measure voltage and current
- Place module under direct sunlight or controlled lamp

2 Prepare PKL Setup

Construct the PKL electricity generation system.

- Collect fresh Pathor Kuchi leaves
- Insert copper and zinc electrodes into leaf tissue
- Connect electrodes to external circuit
- Use electrolyte solution to enhance conductivity

3 Record Electrical Output

Measure and record voltage, current, and power output.

- Use digital multimeter to measure voltage and current
- Record readings at fixed intervals
- Compare outputs under identical light conditions

4 Analyze Efficiency

Evaluate conversion efficiency of both systems.

- Calculate efficiency using Pout / Pin × 100%
- Compare average values for SPV and PKL
- Plot graphs for performance trends

5 Assess Cost and Sustainability

Compare economic and environmental aspects.

- Estimate material and setup costs
- Evaluate recyclability and eco-friendliness
- Discuss scalability for rural and urban applications

IIC. Methodology of Data Collection

1. Data Collection

- **Solar PV System**: Performance data were obtained from commercially available PV modules under controlled laboratory conditions and supplemented with field measurements of output, efficiency, and cost.
- **PKL System**: Experimental setups using natural and artificial leaves were tested to measure voltage, current, and energy output. Laboratory trials were conducted to assess stability, reproducibility, and material costs.

2. Parameters of Comparison

- **Efficiency**: Conversion efficiency of sunlight into electricity was measured for both systems.
- **Cost-effectiveness**: Initial setup cost, maintenance requirements, and long-term economic viability were analyzed.
- **Environmental Impact**: Carbon footprint, recyclability of materials, and ecological sustainability were considered.

- **Scalability & Applicability**: Suitability for rural electrification, urban deployment, and off-grid applications was evaluated.

3. Experimental Procedure

- Both PV and PKL systems were exposed to identical light conditions to ensure fairness in comparison.
- Output readings (voltage, current, power) were recorded at regular intervals.
- Statistical tools were applied to analyze variations and determine average performance.
- Comparative charts and graphs were generated to visualize differences in efficiency, cost, and environmental impact.

4. Analytical Framework

- A **SWOT analysis** (Strengths, Weaknesses, Opportunities, Threats) was conducted for each technology.
- **Cost–benefit analysis** was applied to evaluate economic feasibility.
- **Sustainability assessment metrics** were used to measure environmental compatibility.

5. Comparison between SPV and PKL electricity

Feature	Solar Photovoltaic (SPV)	Pathor Kuchi Leaf (PKL)
Energy Source	Sunlight	Organic acids (malic, citric) in PKL
Operation Time	Daytime only	Day & night, all weather
Reliability in Rainy Season	Poor	Stable
Scalability	Widely scalable	Emerging, small-scale tested
Cost	Higher initial investment	Low-cost, locally available
Applications	Household, industrial, grid	Rural off-grid, mobile charging, LED lighting
Limitations	Needs sunlight, storage batteries	Still experimental, lower efficiency

6. Challenges & Risks

- PKL electricity is still experimental and lacks large-scale deployment.
- Efficiency and durability of PKL systems need improvement compared to mature SPV technology.
- Scalability beyond small rural setups remains uncertain.
- SPV remains dominant globally due to proven reliability, but PKL offers niche advantages in Bangladesh's rural electrification.

In summary: PKL electricity is a promising bio-voltaic innovation for rural Bangladesh, offering continuous low-cost power where SPV struggles (night/rain). However, SPV remains the more efficient and globally scalable option.

III. Results and discussion

1. Efficiency Outcomes

- **Solar PV**: The photovoltaic modules demonstrated an average efficiency of 15–20%, consistent with commercial standards. Output remained stable under varying light intensities, with predictable performance curves.
- **PKL Electricity**: PKL setups produced measurable voltage and current, but efficiency was significantly lower (typically below 25%). Performance was highly dependent on leaf type, electrolyte composition, and environmental conditions, leading to inconsistent results.

Discussion: Solar PV clearly outperforms PKL in terms of conversion efficiency and reliability. However, PKL's ability to generate electricity from simple, low-cost materials highlights its potential as a supplementary energy source in resource-limited settings.

2. Cost Analysis

- **Solar PV**: Initial installation costs are relatively high, but long-term operation is cost-effective due to durability and low maintenance.
- **PKL Electricity**: Setup costs are minimal, as PKL systems can be fabricated using inexpensive, locally available materials. However, durability and scalability remain challenges.

Discussion: While PV systems are economically viable for large-scale deployment, PKL electricity offers affordability for small-scale, experimental, or rural applications where capital investment is limited.

3. Environmental Impact

- **Solar PV**: Manufacturing involves energy-intensive processes and use of rare materials, but operational emissions are negligible. Recycling of PV modules is possible but requires specialized facilities.
- **PKL Electricity**: PKL systems are biodegradable, eco-friendly, and pose minimal environmental hazards. Their reliance on natural or bio-inspired materials reduces ecological footprint.

Discussion: PKL electricity demonstrates superior environmental sustainability compared to PV, though its limited efficiency restricts widespread adoption.

4. Scalability and Applicability

- **Solar PV**: Proven scalability from household systems to utility-scale solar farms. Widely integrated into national grids.
- **PKL Electricity**: Currently limited to laboratory and small-scale prototypes. Scalability is constrained by low efficiency and lack of standardized technology.

Discussion: Solar PV remains the dominant renewable technology for large-scale energy generation. PKL electricity, while not yet commercially viable, could serve niche roles in rural electrification, education, and eco-friendly innovation projects.

5. Overall Comparative Insights

- Solar PV is a mature, efficient, and scalable technology suitable for mainstream energy production.
- PKL electricity is an emerging, eco-friendly, and low-cost alternative with potential for localized applications but requires significant research to improve efficiency and stability.

- Together, they represent complementary approaches: PV for large-scale reliable power, PKL for sustainable innovation in resource-constrained environments.

IV. Conclusion

This comparative study between solar photovoltaic (PV) electricity and PKL (Pathor Kuchi Leaf) electricity highlights the distinct strengths and limitations of both renewable energy technologies. Solar PV, with its proven efficiency, scalability, and commercial maturity, remains the dominant solution for large-scale sustainable power generation. Its reliability and integration into modern energy systems make it indispensable in the global transition toward clean energy.

PKL electricity, though still in its experimental stage, demonstrates unique advantages such as low-cost materials, eco-friendliness, and potential for localized energy generation. While its efficiency and stability are currently limited, PKL technology represents an innovative approach inspired by nature that could complement conventional solar PV systems, particularly in rural or resource-constrained regions.

The findings suggest that solar PV should continue to serve as the backbone of renewable energy infrastructure, while PKL electricity warrants further research and development to enhance its performance and scalability. Together, these technologies embody the importance of diversifying renewable energy sources to achieve long-term sustainability, reduce dependence on fossil fuels, and address global energy challenges.

References

1. Md. Bodhroddoza Shohag, Md. Sayed Hossain, Md. Rakibul Hasan, Md. Mobasher Ahmed, Abdullah Al Mahmud, Mohammad Mezbah Uddin, Md. Abdul Malek Soner, Ashraful Haque, Kamrul Alam Khan (2022), A case study and troubleshooting experience of safety power channel of instrumentation and control system of the BAEC TRIGA Research Reactor, Microsystem Technologies https://doi.org/10.1007/s00542-022-05366-w, Received: 25 October 2021 / Accepted: 10 August 2022
2. Md Afzol Hossain, Bithi Paul, K.A. Khan, Monika Paul, M.A. Mamun, Md Emran Quayum (2022),Green synthesis and characterization of silver nanoparticles by using Bryophyllum pinnatum and the evaluation of its power generation activities on bio-electrochemical cell, Materials Chemistry and Physics, Elsevier, https://doi.org/10.1016/j.matchemphys.2022.125943, Received 24 April 2021; Received in revised form 10 December 2021; Accepted 27 February 2022.
3. Khan K.A.(1999) Copper oxide coatings for use in a linear solar Fresnel reflecting concentrating collector, Published in the journal. of Elsevier, Renewable Energy, An International Journal, WREN(World Renewable Energy Network), UK, RE: 12.97/859,1998, Publication date 1999/8/1, J. Renewable energy, 17(4) :603-608. Publisher - Pergamon, 1999
4. T.A. Ruhane, M.Tauhidul Islam, Md. Saifur Rahman, M.M.H.Bhuiyah, Jahid M.M. Islam, T.I. Bhuiyah, K.A.Khan , Mubarak A. Khan(2017) Impact of photo electrode thickness annealing temperature on natural dye sensitized solar cell, Sustainable Energy Technologies and Assessments, Elsevier, http://dx.doi.org/10.1016/j.seta.2017.01.012
5. T. A. Ruhane, M. Tauhidul Islam, Md. Saifur Rahaman, M.M.H. Bhuiyan, Jahid M.M. Islam, M.K. Newaz, K.A. Khan, Mubarak A. Khan(2017) Photo current enhancement of natural dye sensitized solar cell by optimizing dye extraction and its loading period, Optik - International Journal for Light and Electron Optics, Elsevier

6. Mehedi Hasan & K. A. Khan (2018) Dynamic model of Bryophyllum pinnatum leaf fueled BPL cell: a possible alternate source of electricity at the off-grid region in Bangladesh, Microsystem Technologies Micro - and Nanosystems Information Storage and Processing Systems, Springer, ISSN 0946-7076, Microsyst Technol DOI 10.1007/s00542-018-4149-y
7. K. A. Khan, M. Hazrat Ali, A. K. M. Obaydullah & M. A. Wadud(2019) Production of candle using solar thermal technology, Microsystem Technologies Micro- and Nanosystems Information Storage and Processing Systems, Springer, ISSN 0946-7076, Microsyst Technol, 25(12), DOI 10.1007/s00542-019-04390-7
8. K. A. Khan, S. R. Rasel & M. Ohiduzzaman(2019) Homemade PKL electricity generation for use in DC fan at remote areas, Microsystem Technologies Micro- and Nanosystems Information Storage and Processing Systems, ISSN 0946-7076, Microsyst Technology, 25(12), DOI 10.1007/s00542-019-04422-2
9. Mehedi Hasan & Kamrul Alam Khan (2019) Experimental characterization and identification of cell parameters in a BPL electrochemical device, Springer, SN Applied Sciences (2019) 1:1008 | https://doi.org/10.1007/s42452-019-1045-8
10. Lovelu Hassan and K. A. Khan (2019) A study on harvesting of PKL electricity, Springer Journal, Microsyst Technol (2020) 26:1031-1041 DOI 10.1007/s00542-019-04625-7, 26(3),PP:1032-1041.
11. K. A. Khan, M. A. Mamun, M. Ibrahim, M. Hasan, M. Ohiduzzaman, A. K. M. Obaydullah, M. A. Wadud, M. Shajahan (2019) PKL electrochemical cell: physics and chemistry, Springer Journal, SN Applied Sciences (2019) 1:1335 https://doi.org/ 10.1007/ s42452-019-1363-x
12. M.Hazrat Ali, Unesco Chakma,Debashis Howlader, M. Tawhidul Islam and K.A.Khan (2019) Studies on Performance Parametersof a Practical Transformer for Various Utilizations, Microsystem Technologies, Springer, Accepted:03 Dec 2019, DOI: 10.1007/s00542-019-04711-w
13. Khan, K.A., Hassan, L., Obaydullah, A.K.M. et al. Bioelectricity: a new approach to provide the electrical power from vegetative and fruits at off-grid region. Microsyst Technol (2018). https://doi.org/10.1007/s00542-018-3808-3
14. Khan KA, Bhuyan MS., Mamun M A., Ibrahim M., Hasan L., Wadud M.A.(2018), Organic Electricity from Zn/Cu-PKL Electrochemical Cell, In: Contemporary Advances in Innovative and Applicable Information Technology, Advances in Intelligent Systems and Computing, J. K. Mandal et al. (eds.), © Springer Nature Singapore Pvt. Ltd., 2018, Vol. 812, Chapter 9, p 75-90.
15. AKM Atique Ullah, Md Mahbubul Haque, Mahmuda Akter4, A Hossain, AN Tamanna, Md. Mottaleb Hosen, AKM Fazle Kibria, MNI Khan and M KA Khan (2020) GreensynthesisofBryophyllumpinnatumaqueousleafextractmediatedbiomoleculecappeddiluteferromagneticα-MnO2 nanoparticles, Mater. Res. Express 7(1)(2020),015088, IOP publishing Ltd.
16. K. A. Khan, M Hazrat Ali, M. A. Mamun, M. Mahbubul Haque, A.K.M. Atique Ullah, M.N. Islam Khan, Lovelu Hassan, A.K.M. Obaydullah, M.A.Wadud (2020), Bioelectrical Characterization and Production of Nanoparticles (NPs) Using PKL Extract for Electricity Generation, Received: 31 July 2018/Accepted: 4 February 2020, Microsystems Technology, Springer Journal, DOI 10.1007/s00542-020-04774-0.
17. Hasan, M. & Khan, K. A. (2019) Experimental characterization and identification of cell parameters in a BPL electrochemical device. SN Appl. Sci., 1:1008. https://doi.org/ 10.1007/s42452-019-1045-8
18. K.A. Khan , Shahinul Islam, S. R. Rasel, M. A.Saime, Sazzad Hossain, Md. Atiqur Rahman (2020) Erformance Evaluation Of Pkl (Pathor Kuchi Leaf) Electricity For Use In

Television And Radio, Information Management and Computer Science (IMCS) 3(2) (2020) 30-37, DOI: http://doi.org/10.26480/imcs.02.2020.30.37

19. K.A. Khan, Samiul Alim, Md Khairul Islam, and Sayed Bony Amin. "Living PKL Plants - An Innovative Idea for PKL back up LED lamp along the Coastal Belts of Bangladesh", Internation Journal Of Advance Research And Innovative Ideas In Education Volume 7 Issue 2 2021 Page 112-127
20. K.A. Khan, Shahinul Islam, M. A. Saime, S. R. Rasel, Sazzad Hossain(2021) A NEW AND SUSTAINABLE PKL ELECTRICITY, Topics in Intelligent Computing and Industry Design (ICID) 2(2) (2020) 173-178, DOI: http://doi.org/10.26480/etit.02.2020.173.178
21. Md. Ohiduzzamana, Rajia Sultanab, Rajada Khatunc, Shirin Akterc and K.A.Khan(2021) PORTABLE PKL POWERED LANTERN, Topics in Intelligent Computing and Industry Design (ICID) 2(2) (2020) 179-183, DOI: http://doi.org/10.26480/etit.02.2020.179.183
22. Motiur Rahman, M Shamsuzzaman, Manoshi Sarker, Abdul Jobber , Mohsin Mia, Asish Kumar Bairagi, Musfika Ahmed , Shohel Reza, Sadiq R Malik, MMH Bhuiyan, ASM Habibullah Khan and 200. MKA Khan (2021), Dosimetric characterization of medical linear accelerator Photon and Electron beams for the treatment accuracy of cancer patients, World Journal of Advanced Engineering Technology and Sciences, 2021, 03(01), 041–059, Publication history: Received on 04 May 2021; revised on 11 August 2021; accepted on 13 August 2021, Article DOI: https://doi.org/10.30574/wjaets.2021.3.1.0046
23. Md Ohiduzzaman, M N I Khan, K A Khan and Bithi Paul (2023), Green synthesis of silver nanoparticles by using Allium sativum extract and evaluation of their electrical activities in bio electrochemical cell, IOP Publishing, Received 8 August 2023, revised 25 November 2023, Accepted for publication 29 November 2023, Published 15 December 2023
24. Nilufar.Yesmin.Tanisha, K. A. Khan and M. Salauddin (2024), Synthesis, evaluation, and monitoring of red amaranth extract for power production, Vietnam Academy of Science and Technology Advances in Natural Sciences: Nanoscience and Nanotechnology, Adv. Nat. Sci.: Nanosci. Nanotechnol. 15 (2024) 015001 (9pp), IOP Publishing, https://doi.org/10.1088/2043-6262/ad1a9f
25. Shamima Mehrin,Nilufer Yesmin Tanisa,1Rabiul Awal, Md. Kamrul Alam Khan,Abdus Shaqur, Shamim Ahmed, Shahidul Islam, and Asad Mia (2024), Efficient Bioelectrochemical Cell Generation and Green Synthesis of Silver Nanoparticles Using Pomegranate and Pineapple Peel Extracts: A Comprehensive Characterization Study, Advances in Material Sciences and Engineering, Volume 2024 | Article ID 6681559 | https://doi.org/10.1155/2024/6681559
26. Md Ohiduzzaman , M. N. I. Khan , K. A. Khan ,Bithi Paul (2024),Biosynthesis of silver nanoparticles by banana pulp extract: Characterizations, antibacterial activity, and bioelectricity generation, HELIYON (2024), https:// doi.org/10.1016/ j.heliyon.2024.e25520.
27. N Y Tanisa, K A Khan and M Salahuddin(2024),, Synthesis, evaluation, and monitoring of red amaranth extract for power production, Advances in Natural Sciences: Nanoscience and Nanotechnology, Advances in Natural Sciences: Nanoscience and Nanotechnology, Adv. Nat. Sci.: Nanosci. Nanotechnol. 15 (2024) 015001 (9pp) https://doi.org/ 10.1088/2043-6262/ad1a9
28. Md Ohiduzzaman, M.N.I. Khan, K.A. Khan, Bithi Paul, Md Nazmul Hasan Zilani, Md Nazmul Hasan(2024), Crystallographic structure, antibacterial effect, and catalytic activities of fig extract mediated silver nanoparticles, Received 6 March 2024; Received in revised form 3 June 2024; Accepted 4 June 2024, Available online 4 June 2024, https://doi.org/10.1016/j.heliyon.2024.e32419

29. Amir Hossain, A. Mimi, A.H. Zulkarninea, M.R. Hasan, Mohammad K. Alam, KA Khan, A.A. Momin, (2024), Influence of Ni substitution on Structural, Optical, magnetic and transport properties of $Mn_{0.5-x}Ni_xZn_{0.4}Cu_{0.1}Fe_{1.95}Al_{0.05}O_4$ (Received 3 April 2024, Revised 6 August 2024, Accepted 27 August 2024, Available online 30 August 2024, Version of Record 31 August 2024), Volume 609, 1 November 2024, 172479, Journal of Magnetism and magnetic materials, Elsevier.
30. Md. Moiful Alam, Md. Mosarof Hossain Sarkar, Asif Parvez, Md. Kamrul Alam Khan. "Mn-enhanced Li-Ni-Mn-Zn nano-ferrites: Synthesis, characterization, and evaluations of structural, morphological, magnetic, and dielectric features", Journal of Magnetism and Magnetic Materials, Volume 593, 2024, 171783, ISSN 0304-8853. https://doi.org/10.1016/j.jmmm.2024.171783.