Documents

Aman, A.H.M.[a] , Shaari, N.[b] , Attar Bashi, Z.S.[c] , Iftikhar, S.[d] , Bawazeer, S.[d] , Osman, S.H.[e] , Hasan, N.S.[f]

A review of residential blockchain internet of things energy systems: Resources, storage and challenges
(2024) *Energy Reports*, 11, pp. 1225-1241. Cited 1 time.

DOI: 10.1016/j.egyr.2023.12.062

[a] Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, Selangor, Bangi, UKM 43600, Malaysia
[b] Fuel Cell Institute, Universiti Kebangsaan Malaysia, Selangor, Bangi, UKM 43600, Malaysia
[c] Faculty of Information and Communication Technology, International Islamic University Malaysia, Selangor, Gombak, 53100, Malaysia
[d] Faculty of Computer Studies, Arab Open University, Saudi Arabia
[e] Science University of Malaysia, Malaysia
[f] PETRONAS Research Sdn. Bhd., Kawasan Institusi Bangi, Selangor, Kajang, 43000, Malaysia

Abstract
The Internet of Things (IoT) and Blockchain paradigms have offered significant benefits in recent technological innovations. Blockchain has been rated one of the top ten strategic technologies in a recent Gartner survey, and it is increasingly being employed in a range of industries. Blockchains provide transparent, tamper-proof, and secure platforms that, enables ground-breaking commercial solutions. Nonetheless, the use of blockchain technology for IoT Smart Residential energy systems looks to be relatively unexplored. In fact, most IoT devices are powered by a battery with a short life span. Generating and managing energy on an infinite scale is a much more ambitious goal than relying solely on battery power. Hence, this topic is addressed in this article, focusing on the IoT energy systems, renewable energy resources, and how energy is successfully stored. By thoroughly evaluating the literature and existing research cases, this article contributes to the state-of-the-art. Our study examines the opportunities, challenges, and constraints for the evolving peer-to-peer energy systems and blockchain-IoT applications. The study concludes with the hurdles that technology must overcome in order to move beyond the hype phase and into mainstream acceptance. © 2024 The Authors

Author Keywords
Blockchain energy system; Blockchain internet of things; Internet of things energy system; Residential blockchain energy

Index Keywords
Blockchain, Electric batteries, Housing, Renewable energy; Block-chain, Blockchain energy system, Blockchain internet of thing, Energy, Energy systems, Internet of thing energy system, Residential blockchain energy; Internet of things

Funding details
AOUKSA-524008
Universiti Kebangsaan MalaysiaUKMFRGS/1/2019/ICT03/UKM/02/1
Universiti Kebangsaan MalaysiaUKM
Funding details
The study has been supported by Arab Open University for funding this work through AOU research fund No. (AOUKSA-524008). The authors extend their appreciation to the National University of Malaysia (UKM) on the Internet of Things Network FRGS/1/2019/ICT03/UKM/02/1.
Funding details
The study has been supported by Arab Open University for funding this work through AOU research fund No. (AOUKSA-524008). The authors extend their appreciation to the National University of Malaysia (UKM) on the Internet of Things Network FRGS/1/2019/ICT03/UKM/02/1 .

References

- Abdin, Z., Webb, C., Gray, E.
  Solar hydrogen hybrid energy systems for off-grid electricity supply: a critical review
  (2015) *Renew. Sustain. Energy Rev.*, 52 (100), pp. 1791-1808.
- Afzal, M.
  Blockchain enabled distributed demand side management in community energy system with smart homes
  (2020) *IEEE Access*, 8, pp. 37428-37439.

- Akhtar, F., Rehmani, M.H.
  Energy replenishment using renewable and traditional energy resources for sustainable wireless sensor networks: a review
  (2015) *Renew. Sustain. Energy Rev.*, 45, pp. 769-784.

- Albreem, M.
  (2017), Green internet of things (IoT): An overview.

- Albreem, M.A.
  Green internet of things (GIoT): applications, practices, awareness, and challenges
  (2021) *IEEE Access*, 9, pp. 38833-38858.

- Ali, M.T., Fath, H.E., Armstrong, P.R.
  A comprehensive techno-economical review of indirect solar desalination
  (2011) *Renew. Sustain. Energy Rev.*, 15 (8), pp. 4187-4199.

- Alkawsi, G., Ali, N., Baashar, Y.
  The moderating role of personal innovativeness and users experience in accepting the smart meter technology
  (2021) *Appl. Sci.*, 11 (8), p. 29.

- Alladi, T.
  Blockchain in smart grids: a review on different use cases
  (2019) *Sensors*, 19 (22), p. 25.

- Alsamhi, S.H.
  Green internet of things using UAVs in B5G networks: a review of applications and strategies
  (2021) *Ad Hoc Netw.*, 117.

- Aman, A.H.M.
  A survey on trend and classification of internet of things reviews
  (2020) *IEEE Access*, 8, pp. 111763-111782.

- Andoni, M.
  Blockchain technology in the energy sector: a systematic review of challenges and opportunities
  (2019) *Renew. Sustain. Energy Rev.*, 100, pp. 143-174.

- Andoni, M., Robu, V., Flynn, D.
  Blockchains: Crypto-control your own energy supply. (1476–4687 (Electronic)).

- Aneke, M., Wang, M.
  Energy storage technologies and real life applications – a state of the art review
  (2016) *Appl. Energy*, 179, pp. 350-377.

- Arif, S.
  Investigating smart home security: is blockchain the answer?
  (2020) *IEEE Access*, 8, pp. 117802-117816.

- Armand, M., Tarascon, J.-M.
  Building better batteries
  (2008) *nature*, 451 (7179), pp. 652-657.

- Armbrust, M.
  A view of cloud computing
  (2010) *Commun. ACM*, 53 (4), pp. 50-58.

- Asif, R., Ghanem, K., Irvine, J.
  Proof-of-PUF enabled blockchain: concurrent data and device security for internet-of-energy
  (2021) *Sensors*, 21 (1), p. 32.

- Barbour, E.R., Pottie, D.L., Eames, P.
Why is adiabatic compressed air energy storage yet to become a viable energy storage option?
(2021) *Iscience*, 24 (5).

- Bilgili, M.
An overview of renewable electric power capacity and progress in new technologies in the world
(2015) *Renew. Sustain. Energy Rev.*, 49, pp. 323-334.

- Bin Qaim, W.
Towards energy efficiency in the internet of wearable things: a systematic review
(2020) *IEEE Access*, 8, pp. 175412-175435.

- Carli, D.
A high-efficiency wind-flow energy harvester using micro turbine
(2010) *SPEEDAM 2010*,
IEEE

- Casquico, M.
Blockchain and internet of things for electrical energy decentralization: a review and system architecture
(2021) *Energies*, 14 (23), p. 26.

- Casquiço, M.
Blockchain and internet of things for electrical energy decentralization: a review and system architecture
(2021) *Energies*, 14 (23).

- Chauhan, A., Saini, R.
A review on integrated renewable energy system based power generation for stand-alone applications: configurations, storage options, sizing methodologies and control
(2014) *Renew. Sustain. Energy Rev.*, 38, pp. 99-120.

- Cheng, L.
Configuration method of hybrid energy storage system for high power density in More Electric Aircraft
(2020) *J. Power Sources*, 445.

- Cheng, P., Zhan, X.
Stability of organic solar cells: challenges and strategies
(2016) *Chem. Soc. Rev.*, 45 (9), pp. 2544-2582.

- Ciccarelli, F., Pizzo, A.D., Iannuzzi, D.
Improvement of energy efficiency in light railway vehicles based on power management control of wayside lithium-ion capacitor storage
(2014) *IEEE Trans. Power Electron.*, 29 (1), pp. 275-286.

- Dagdeviren, C.
Conformal piezoelectric energy harvesting and storage from motions of the heart, lung, and diaphragm
(2014) *Proc. Natl. Acad. Sci. USA*, 111 (5), pp. 1927-1932.

- Dahn, J.
The drugstore Li-ion cell
(2005) *Electrochem. Soc. Interface*, 14 (4), p. 27.

- Díaz-González, F.
A hybrid energy storage solution based on supercapacitors and batteries for the

grid integration of utility scale photovoltaic plants
(2022) *J. Energy Storage*, 51.

- Diouf, B.
A second life for mobile phone batteries in light emitting diode solar home systems
(2016) *J. Renew. Sustain. Energy*, 8 (2).

- Eid, C.
Managing electric flexibility from distributed energy resources: a review of incentives for market design
(2016) *Renew. Sustain. Energy Rev.*, 64, pp. 237-247.

- Escobar, J.J.M.
A comprehensive review on smart grids: challenges and opportunities
(2021) *Sensors*, 21 (21), p. 41.

- Fernández-Caramés, T.M., Fraga-Lamas, P.
A review on the use of blockchain for the internet of things
(2018) *IEEE Access*, 6, pp. 32979-33001.

- Ferrag, M.A., Shu, L.
The performance evaluation of blockchain-based security and privacy systems for the internet of things: a tutorial
(2021) *IEEE Internet Things J.*, 8 (24), pp. 17236-17260.

- Gandhidasan, P., Al-Mojel, S.A.
Effect of feed pressure on the performance of the photovoltaic powered reverse osmosis seawater desalination system
(2009) *Renew. Energy*, 34 (12), pp. 2824-2830.

- Gielen, D.
Global Energy Transformation: A Roadmap to 2050
(2019), International Renewable Energy Agency (IRENA)

- Gray, E.M.
Hydrogen storage for off-grid power supply
(2011) *Int. J. Hydrog. Energy*, 36 (1), pp. 654-663.

- Green, M.A.
Solar cell efficiency tables (version 50)
(2017) *Prog. Photovolt.: Res. Appl.*, 25 (7), pp. 668-676.

- Grieser, B., Sunak, Y., Madlener, R.
Economics of small wind turbines in urban settings: an empirical investigation for Germany
(2015) *Renew. Energy*, 78, pp. 334-350.

- Haider, H.T., See, O.H., Elmenreich, W.
A review of residential demand response of smart grid
(2016) *Renew. Sustain. Energy Rev.*, 59, pp. 166-178.

- Hasan, M.K.
Blockchain technology on smart grid, energy trading, and big data: security issues, challenges, and recommendations
(2022) *Wirel. Commun. Mob. Comput.*, 2022, p. 9065768.

- Hasan, N.S.
Review of storage schemes for wind energy systems
(2013) *Renew. Sustain. Energy Rev.*, 21, pp. 237-247.

- Hasankhani, A.
Blockchain technology in the future smart grids: a comprehensive review and

frameworks
(2021) *Int. J. Electr. Power Energy Syst.*, 129, p. 29.

- Hoffmann, D.
Energy harvesting from fluid flow in water pipelines for smart metering applications
(2013) *Journal of Physics: Conference Series*,
IOP Publishing

- Hosseinzadeh, A.
Techno-economic and environmental impact assessment of hydrogen production processes using bio-waste as renewable energy resource
(2022) *Renew. Sustain. Energy Rev.*, 156.

- Ibrahim, R., Shaari, N., Mohd Aman, A.H.
Bio-fuel cell for medical device energy system: a review
(2021) *Int. J. Energy Res.*, 45 (10), pp. 14245-14273.

- Jasni, M.R.M.
Supercapacitor electrodes from activation of binderless green monoliths of biomass self-adhesive carbon grains composed of varying amount of graphene additive
(2018) *Ionics*, 24 (4), pp. 1195-1210.

- Joseph, A., Balachandra, P.
Smart grid to energy internet: a systematic review of transitioning electricity systems
(2020) *IEEE Access*, 8, pp. 215787-215805.

- Ju, Y., Maruta, K.
Microscale combustion: technology development and fundamental research
(2011) *Prog. Energy Combust. Sci.*, 37 (6), pp. 669-715.

- Kalghatgi, G.
Is it really the end of internal combustion engines and petroleum in transport?
(2018) *Appl. Energy*, 225, pp. 965-974.

- Kausar, A.Z.
Energizing wireless sensor networks by energy harvesting systems: scopes, challenges and approaches
(2014) *Renew. Sustain. Energy Rev.*, 38, pp. 973-989.

- Khoon, L.T.
In situ sol–gel preparation of ZrO2 in nano-composite polymer electrolyte of PVDF-HFP/MG49 for lithium-ion polymer battery
(2019) *J. Sol. -Gel Sci. Technol.*, 90 (3), pp. 665-675.

- Kocakulak, M., B.I
An overview of wireless sensor networks towards internet of things
(2017) *IEEE 7th Annual Computing and Communication Workshop and Conference (CCWC)*,
IEEE: New York City

- Komal, S., Abdul, B., Shukla, V.K.
Green internet of things (G-IoT) technologies, application, and future challenges
(2021) *Green Internet Things Mach. Learn.: Towards a Smart Sustain. World*, pp. 317-348.

- Koshy, P., Babu, S., Manoj, B.S.
Sliding window blockchain architecture for internet of things
(2020) *IEEE Internet Things J.*, 7 (4), pp. 3338-3348.

- Ku, M.-L.
  Advances in energy harvesting communications: past, present, and future challenges
  (2015) *IEEE Commun. Surv. Tutor.*, 18 (2), pp. 1384-1412.

- Kumar, N.M.
  Distributed energy resources and the application of AI, IoT, and blockchain in smart grids
  (2020) *Energies*, 13 (21), p. 42.

- Lee, T.K.
  PEO based polymer electrolyte comprised of epoxidized natural rubber material (ENR50) for Li-Ion polymer battery application
  (2019) *Electrochim. Acta*, 316, pp. 283-291.

- Lehmann, M.
  Ocean wave energy in the United States: current status and future perspectives
  (2017) *Renew. Sustain. Energy Rev.*, 74, pp. 1300-1313.

- Lei, M.
  A review on the forecasting of wind speed and generated power
  (2009) *Renew. Sustain. Energy Rev.*, 13 (4), pp. 915-920.

- Li, J.N.
  Decentralized on-demand energy supply for blockchain in internet of things: a microgrids approach
  (2019) *IEEE Trans. Comput. Soc. Syst.*, 6 (6), pp. 1395-1406.

- Li, P.
  A cascade organic Rankine cycle power generation system using hybrid solar energy and liquefied natural gas
  (2016) *Sol. Energy*, 127, pp. 136-146.

- Li, X., Wei, B.
  Supercapacitors based on nanostructured carbon
  (2013) *Nano Energy*, 2 (2), pp. 159-173.

- Li, Z.
  Consortium blockchain for secure energy trading in industrial internet of things
  (2018) *IEEE Trans. Ind. Inform.*, 14 (8), pp. 3690-3700.

- Lim, E.L.
  A review of recent plasmonic nanoparticles incorporated P3HT: PCBM organic thin film solar cells
  (2016) *Org. Electron.*, 36, pp. 12-28.

- Lo Cascio, E.
  How smart is the grid?
  (2021) *Front. Energy Res.*, 9, p. 18.

- Lu, X.
  Wireless networks with RF energy harvesting: a contemporary survey
  (2014) *IEEE Commun. Surv. Tutor.*, 17 (2), pp. 757-789.

- Lu, X., Yang, S.-H.
  Thermal energy harvesting for WSNs
  (2010) *2010 IEEE International Conference on Systems, Man and Cybernetics*, IEEE

- Mahbub, M., Hossain, M.M., Gazi, M.S.A.
  IoT-Cognizant cloud-assisted energy efficient embedded system for indoor

intelligent lighting, air quality monitoring, and ventilation
(2020) *Internet Things*, 11.

- Masaki, M.S., Zhang, L., Xia, X.
A hierarchical predictive control for supercapacitor-retrofitted grid-connected hybrid renewable systems
(2019) *Appl. Energy*, 242, pp. 393-402.

- Mathews, I.
Performance of III–V solar cells as indoor light energy harvesters
(2015) *IEEE J. Photovolt.*, 6 (1), pp. 230-235.

- Meng, C.
Ultrasmall integrated 3D micro-supercapacitors solve energy storage for miniature devices
(2014) *Adv. Energy Mater.*, 4 (7).

- Mohamad, F.
Development of energy storage systems for power network reliability: a review
(2018) *Energies*, 11 (9).

- Mohd Aman, A.H., Shaari, N., Ibrahim, R.
Internet of things energy system: smart applications, technology advancement, and open issues
(2021) *Int. J. Energy Res.*, 45 (6), pp. 8389-8419.

- Motlagh, N.H.
Internet of things (IoT) and the energy sector
(2020) *Energies*, 13 (2), p. 27.

- Muñoz, M.
Off-design analysis of a Hybrid Rankine-Brayton cycle used as the power block of a solar thermal power plant
(2017) *Energy*, 134, pp. 369-381.

- Musleh, A.S., Yao, G., Muyeen, S.M.
Blockchain applications in smart grid-review and frameworks
(2019) *IEEE Access*, 7, pp. 86746-86757.

- Nagarajan, M.
Renovated XTEA encoder architecture-based lightweight mutual authentication protocol for RFID and green wireless sensor network applications
(2022) *Wirel. Commun. Mob. Comput.*, 2022.

- Paiho, S.
Towards cross-commodity energy-sharing communities - a review of the market, regulatory, and technical situation
(2021) *Renew. Sustain. Energy Rev.*, 151, p. 20.

- Pan, J.
An internet of things framework for smart energy in buildings: designs, prototype, and experiments
(2015) *IEEE Internet Things J.*, 2 (6), pp. 527-537.

- Pieroni, A., Scarpato, N., Felli, L.
Blockchain and IoT convergence-a systematic survey on technologies, protocols and security
(2020) *Appl. Sci.*, 10 (19), p. 23.

- Pode, R., Diouf, B.
Solar Lighting

(2011), Springer Science & Business Media

- Raj, A., Steingart, D.
  Power sources for the internet of things
  (2018) *J. Electrochem. Soc.*, 165 (8), p. B3130.

- Ray, P.P.
  A survey on internet of things architectures
  (2018) *J. King Saud. Univ. - Comput. Inf. Sci.*, 30 (3), pp. 291-319.

- Reddy, V.S.
  State-of-the-art of solar thermal power plants—a review
  (2013) *Renew. Sustain. Energy Rev.*, 27, pp. 258-273.

- Rejeb, A.
  Unleashing the power of internet of things and blockchain: a comprehensive analysis and future directions
  (2024) *Internet Things Cyber-Phys. Syst.*, 4, pp. 1-18.

- Ren, G.
  Overview of wind power intermittency: impacts, measurements, and mitigation solutions
  (2017) *Appl. Energy*, 204, pp. 47-65.

- Roundy, S.
  , p. 4.
  A 1.9 GHz RF transmit beacon using environmentally scavenged energy. optimization, 2003b. 4(2):

- Roundy, S.
  On the effectiveness of vibration-based energy harvesting
  (2005) *J. Intell. Mater. Syst. Struct.*, 16 (10), pp. 809-823.

- Roundy, S., Wright, P.K., Rabaey, J.M.
  Energy scavenging for wireless sensor networks
  (2003) *Norwell*, pp. 45-47.
  Springer

- Saleem, Y.
  Internet of things-aided smart grid: technologies, architectures, applications, prototypes, and future research directions
  (2019) *IEEE Access*, 7, pp. 62962-63003.

- Schilling, M.A., Esmundo, M.
  Technology S-curves in renewable energy alternatives: analysis and implications for industry and government
  (2009) *Energy Policy*, 37 (5), pp. 1767-1781.

- Shakerighadi, B.
  Internet of things for modern energy systems: state-of-the-art, challenges, and open issues
  (2018) *Energies*, 11 (5).

- Shao, Y.
  Design and mechanisms of asymmetric supercapacitors
  (2018) *Chem. Rev.*, 118 (18), pp. 9233-9280.

- Steele, R.V.
  The story of a new light source
  (2007) *Nat. Photonics*, 1 (1), pp. 25-26.

- Svarc, J.

  Most Efficient Solar Panels 2022. 2022 [cited 2022 31/5/2022]; Available from:

- Talari, S.
  A review of smart cities based on the internet of things concept
  (2017) *Energies*, 10 (4).

- Thackeray, M.M., Wolverton, C., Isaacs, E.D.
  Electrical energy storage for transportation—approaching the limits of, and going beyond, lithium-ion batteries
  (2012) *Energy Environ. Sci.*, 5 (7), pp. 7854-7863.

- Thilakarathne, N.N., Kagita, M.K., Priyashan, W.
  Green internet of things: the next generation energy efficient internet of things
  (2022) *Applied Information Processing Systems*, pp. 391-402.
  Springer

- Tyagi, A.K.
  Blockchain internet of things applications: opportunities and challenges for industry 4.0 and society 5.0.
  (2023) *Sensors*, 23.

- Viriyasitavat, W., Anuphaptrirong, T., Hoonsopon, D.
  When blockchain meets Internet of Things: Characteristics, challenges, and business opportunities
  (2019) *J. Ind. Inf. Integr.*, 15, pp. 21-28.

- Viswanath, S.K.
  System design of the internet of things for residential smart grid
  (2016) *IEEE Wirel. Commun.*, 23 (5), pp. 90-98.

- Wang, D., Zhong, D., Souri, A.
  Energy management solutions in the internet of things applications: technical analysis and new research directions
  (2021) *Cogn. Syst. Res.*, 67, pp. 33-49.

- Wang, Q., Li, R.R., Zhan, L.N.
  Blockchain technology in the energy sector: from basic research to real world applications
  (2021) *Comput. Sci. Rev.*, 39, p. 25.

- Wang, Z.L., Chen, J., Lin, L.
  Progress in triboelectric nanogenerators as a new energy technology and self-powered sensors
  (2015) *Energy Environ. Sci.*, 8 (8), pp. 2250-2282.

- Wen, J., Yu, Y., Chen, C.
  A review on lithium-ion batteries safety issues: existing problems and possible solutions
  (2012) *Mater. Express*, 2 (3), pp. 197-212.

- Yaici, W.
  Recent advances in internet of things (IoT) infrastructures for building energy systems: a review
  (2021) *Sensors*, 21 (6), p. 40.

- Yánez, W.
  Data allocation mechanism for internet-of-things systems with blockchain
  (2020) *IEEE Internet Things J.*, 7 (4), pp. 3509-3522.

- Youm, I.
  Renewable energy activities in Senegal: a review
  (2000) *Renew. Sustain. Energy Rev.*, 4 (1), pp. 75-89.

- Zeng, P.
  Unconventional wearable energy harvesting from human horizontal foot motion
  (2011) *2011 Twenty-Sixth Annual IEEE Applied Power Electronics Conference and Exposition (APEC)*,
  IEEE

- Zhang, Q., Li, G.
  Experimental study on a semi-active battery-supercapacitor hybrid energy storage system for electric vehicle application
  (2020) *IEEE Trans. Power Electron.*, 35 (1), pp. 1014-1021.

- Zhao, H.
  Review of energy storage system for wind power integration support
  (2015) *Appl. Energy*, 137, pp. 545-553.

- Zhi, M.
  Nanostructured carbon–metal oxide composite electrodes for supercapacitors: a review
  (2013) *Nanoscale*, 5 (1), pp. 72-88.

- Zhu, Q.Y.
  Applications of distributed ledger technologies to the internet of things: a survey
  (2020) *Acm Comput. Surv.*, 52 (6).

- Zou, H.
  A dual-electrolyte based air-breathing regenerative microfluidic fuel cell with 1.76 V open-circuit-voltage and 0.74 V water-splitting voltage
  (2016) *Nano Energy*, 27, pp. 619-626.

Correspondence Address
Iftikhar S.; Faculty of Computer Studies, Saudi Arabia; email: s.iftikhar@arabou.edu.sa

Publisher: Elsevier Ltd

ISSN: 23524847
Language of Original Document: English
Abbreviated Source Title: Energy Rep.
2-s2.0-85183687538
Document Type: Review
Publication Stage: Final
Source: Scopus