Sustainable energy planning with sustainable aviation fuels, low-energy buildings, decarbonisation, micro-hydro and PV

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ABSTRACT

This 48th volume of the International Journal of Sustainable Energy Planning and Management presents the most recent work on energy planning with a focus on the production of aviation fuels, where biomass resources in Indonesia are assessed, and buildings' energy demand in cold climates, providing a framework for its assessment. Further work presents findings on wider energy system decarbonisation choices, district heating system decarbonisation choices, electricity system decarbonisation choices as well as more targeted analyses of hydropower in Indonesia and blockchain-assisted PV-based micro-systems in Ethiopia.

1. Issue Contents

Electrification combined with renewable energy expansion is a leading strategy to minimise carbon emissions from heating, cooling, industry and transport or to decrease strategic sensitivity [1], but certain segments are hard to electrify directly, calling for indirect solutions through electrofuels. A new study shows hydrogen demand in the order of 50 Mt per year just in Europe [2] – calling for very large expansion of variable renewable energy sources (VRES). Aviation is on area calling for a switch to sustainable fuels (sustainable aviation fuels - SAF), but a full indirect electrification would call for GW-scale investments in electrolysers as well as VRES capacity [3]. Biomass availability is limited, and is currently used in sectors like heating, where other alternatives are viable [4] calling for a strict prioritisation of biomass to areas where alternatives are not clear [5]. Aviation may be a sector where biomass could have a role to play – possibly as a carbon source for electro sustainable aviation fuels (eSAF) or without hydrogen synthesis.

In this issue, in Ref. [6], Inayah and coauthors investigate the availability of raw materials for SAF production in Indonesia. Raw materials are primarily palm residues and rice residues, and combined with municipal solid waste, this can add up to a production of over 37 Mt annually. The authors stress the full utilisation of particularly palm residues if future needs are to be meet.

In this journal, Bramstoft and Skytte [7] previously looked at the decarbonisation of the transportation sector from a Swedish perspective, looking at both electrification and biomass-derived fuels, finding economic drivers for biomass use. Skov and Hansen previously addressed aviation from a power-to-x perspective in Denmark, finding threats in the form of, e.g., regulation and taxes.

Buildings account for a large share of the global energy demand through heating and cooling. In this issue, Atashbar and coauthors [8] focus on buildings in cold mountain areas. Focusing on approaches to evaluating transferability as well as performance, the authors point at high-performance insulation, dynamic glazing and building-integrated energy production through PV and solar thermal collectors. While these are

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recommendations based on case studies of Turkey, Canada, and Switzerland, their analytical framework can be applied elsewhere for local recommendations more generally.

The IJSEPM has a substantial publication record within the wider field of energy-sector integration of buildings – e.g. through heat savings and/or through district heating systems. Nielsen and coauthors call for heat savings combined with expansion of district heating where possible – combined with the exploitation of various waste heat resources [9] – results also supported by Nielsen's work on optimising savings versus district heating expansion in [10].

Gendebien focused more on the categorisation of buildings in a national building stock [11] with a view to analysing retrofit scenarios. Where Atashbar focuses on cold climates, Kadraoui [12] focused on the more varying climate of Algeria, focusing on both heating and cooling needs, finding that an *"integration of passive and active architectural concepts is an absolute neces-sity to improve the building's energy performance"*.

In [13], the authors use a stakeholder survey of Malaysia's residential construction sector (October–November 2023) and the Relative Importance Index (RII), supported by a Shapiro–Wilk normality test, to explain why "green" housing uptake remains low despite moderate-to-high self-reported awareness. They find that the main barriers are institutional and policy-related (limited policy pressure and weak enforcement), fol-lowed by economic and financial constraints. Accordingly, stakeholders prioritise enabling instruments (targeted incentives, concessional finance/subsidies, and dedicated promotion/implementation teams), which the authors summarise in an integrated barriers–measures framework [13].

These findings are consistent with wider evidence on how economic signals shape behaviour and investment. Hungary's regulated residential price cuts are associated with a measurable "price effect" that raises household energy use and may dilute incentives for efficiency investment unless savings are channelled into refurbishment and demand reduction measures [14]. Complementarily, the previously addressed Algerian diagnosis by Kadraoui [12] shows that over 70% of ther-mal losses arise from the building envelope, confirming that technical solutions are well known but diffusion depends on enabling conditions. Finally, recent work reinforces the policy-design message: recycling energy-tax revenues into targeted efficiency upgrades

and technical support can reduce both energy poverty and demand [15], while incentive schemes require robust governance and oversight to prevent distortions and excessive system costs [16].

In [17], Saglam and coauthors apply EnergyPLAN simulations combined with multi-objective evolutionary algorithms (MOEA) to investigate potential decarbonisation strategies for the district heating system in Oslo, Norway. Their analyses demonstrate the superior feasibility of waste heat utilisation combined with electrification of the heating sector.

The energy systems simulation model EnergyPLAN [18] is widely applied in the academic literature [19] – also in the present journal, where it has been used to explore energy transition in an Alpine community by also applying multi-objectives [20], the role of residen-tial heat pumps in Hungary [21], desalination [22], and in another Norwegian context, the role of 4th generation district heating in a high-hydro system like Norway [23]. Other work combining it with multi-objective optimisation includes the EPLANopt framework presented in [24].

Tamtam and Tourabi [25] question models' ability to properly represent stakeholder preferences in multi-criteria decision making, calling for the authors to present a framework incorporating fuzzy Dombi aggre-gation with the Multi-Attribute Ideal-Real Comparative Analysis (MAIRCA) method. The framework is applied to a number of renewable energy technologies in a Moroccan context, showing its applicability. In this context, Richter and coauthors [26] developed a multi-criteria-based approach for assessing industrial energy efficiency measures, Saleki [27] applied multi criteria analyses in a developed micro-level decision support system for PV and wind, and Güleç and coauthors used it for wind power siting in Turkey [28].

Nugroho and coauthors [29] explore micro-hydropower plants in an Indonesian setting, focusing on barriers and drivers. Success depends on many factors, not least community participation. Indonesia has been the focus point of multiple articles of the journal of which [30] deserves particular atten-tion in this context. In this Putranto compared install-ing large hydropower according to optimal resources versus demand centre locations, where the work in [29] addresses smaller units where optimality from both perspectives is more easily attained. Siregar ranked hydropower second after solar for sustainable electricity generation in Indonesia [31].

In this issue, Toukan and coauthors [32] use a PyPSA [33]-derived PyPSA-Earth model to model low-carbon development scenarios for Côte d'Ivoire scenarios. PV is identified as the dominant technology in this analysis based on high temporal resolution and a spatial system aggregated into 14 clusters. Previously in this journal, Hassan and coauthors used PyPSA [34] to model storage in a generic country. Groissböck [35] assessed various modelling frameworks, identifying PyPSA as a candidate for inclusion in an open-source framework for modelling energy systems.

Yuliang and coauthors [36] analyse prospects for blockchain-facilitated micro-grids in Ethiopia. The optimal technical composition gives a micro-system drawing primarily on PV, and the blockchain settlement approach provides *"transparency and rule-based allocation"*. This is in line with Matak, stating that *"blockchain technology is anticipated to ensure secure and transparent data management"* [37].

References

[1] Nikas A, Frilingou N, Heussaff C, Fragkos P, Mittal S, Sampedro J, et al. Three different directions in which the European Union could replace Russian natural gas. Energy 2024;290:130254. https://doi.org/10.1016/J.ENERGY.2024.130254.

[2] Abid H, Østergaard PA, Skov IR, Mathiesen BV. Comparative assessment of future hydrogen demand potentials in a decarbonised European energy system. Int J Hydrogen Energy 2025;122:82–96. https://doi.org/10.1016/j.ijhydene.2025.03.362.

[3] Abid H, Skov IR, Mathiesen BV, Østergaard PA. Standalone and system-level perspectives on hydrogen-based sustainable aviation fuel pathways for Denmark. Energy 2025;320:135450. https://doi.org/10.1016/j.energy.2025.135450.

[4] Mathiesen BV, Lund H, Connolly D. Limiting biomass consumption for heating in 100% renewable energy systems. Energy 2012;48:160–8. https://doi.org/10.1016/j.energy.2012.07.063.

[5] Kwon PS, Østergaard PA. Priority order in using biomass resources – Energy systems analyses of future scenarios for Denmark. Energy 2013;63:86–94. https://doi.org/10.1016/j.energy.2013.10.005.

[6] Inayah I, et al. A preliminary assessment of sustainable aviation fuel potentials from municipal, agricultural, and plantation wastes in Indonesia. International Journal of Sustainable Energy Planning and Management 2026;48. https://doi.org/10.54337/ijsepm.10615.

[7] Bramstoft R, Skytte K. Decarbonizing Sweden ' s energy and transportation system by 2050. International Journal of Sustainable Energy Planning and Management 2017;14:3–20. https://doi.org/10.5278/ijsepm.2017.14.2.

[8] Atashbar F, Et al. Prioritizing Sustainable Technological Solutions for Zero-Energy Buildings in Semi-Temperate Mountainous Climates Based on Technology Transfer Criteria. International Journal of Sustainable Energy Planning and Management 2026;48. https://doi.org/10.54337/ijsepm.10595.

[9] Nielsen S, Sorknæs P, Mathiesen BV, Lund H, Saltos DCM, Thellufsen JZ. Heating Sector Strategies in Climate-Neutral Societies. International Journal of Sustainable Energy Planning and Management 2024;43. https://doi.org/10.54337/ijsepm.8554.

[10] Nielsen S, Thellufsen JZ, Sorknæs P, Djørup SR, Sperling K, Østergaard PA, et al. Smart Energy Aalborg: Matching End-Use Heat Saving Measures and Heat Supply Costs to Achieve Least Cost Heat Supply. International Journal of Sustainable Energy Planning and Management 2020;25. https://doi.org/10.5278/ijsepm.3398.

[11] Gendebien S, Georges E, Bertagnolio S, Lemort V. Methodology to characterize a residential building stock using a bottom-up approach: A case study applied to Belgium. International Journal of Sustainable Energy Planning and Management 2014;4:71–87. https://doi.org/10.5278/ijsepm.2014.4.7.

[12] Kadraoui H, Bekkouche SMEA, Chikhaoui A. Analysis of energy consumption for Algerian building in extreme North-African climates. International Journal of Sustainable Energy Planning and Management 2019;19. https://doi.org/10.5278/ijsepm.2019.19.5.

[13] Xin CS, Et al. Challenges and Solutions for Sustainable Residential Development in Malaysia: A Construction Stakeholder's Viewpoint. International Journal of Sustainable Energy Planning and Management 2026;48. https://doi.org/10.54337/ijsepm.10660.

[14] Szép TS. The effects of utility cost reduction on residential energy consumption in Hungary – a decomposition analysis. International Journal of Sustainable Energy Planning and Management 2017;13:61–78. https://doi.org/10.5278/IJSEPM.2017.13.5.

[15] Borge-Diez D, Silva S, Cabrera P, Sarmento P, Rosales-Asensio E. Energy taxes recycling as an instrument for the mitigation of the expenditure on energy products of vulnerable households in the European Union. Energy Res Soc Sci 2024;118:103787. https://doi.org/10.1016/J.ERSS.2024.103787.

[16] Rosales-Asensio E, Diez DB, Cabrera P, Sarmento P. Effectiveness and efficiency of support schemes in promoting renewable energy sources in the Spanish electricity market. International Journal of Electrical Power & Energy Systems 2024;158:109926. https://doi.org/10.1016/J.IJEPES.2024.109926.

[17] Saglam Y, Et al. A multi-objective optimization approach in defining the decarbonization strategy of a district heating network: A case study of Oslo. International Journal of Sustainable Energy Planning and Management 2026;48. https://doi.org/10.54337/ijsepm.11162.

[18] Lund H, Thellufsen JZ, Østergaard PoulA, Sorknæs P, Skov IR, Mathiesen BV. EnergyPLAN – Advanced Analysis of

Smart Energy Systems. Smart Energy 2021:100007. https://doi.org/10.1016/j.segy.2021.100007.

[19] Østergaard PA, Lund H, Thellufsen JZ, Sorknæs P, Mathiesen BV. Review and validation of EnergyPLAN. Renewable and Sustainable Energy Reviews 2022;168. https://doi.org/10.1016/j.rser.2022.112724.

[20] Viesi D, Mahbub MS, Brandi A, Thellufsen JZ, Østergaard PA, Lund H, et al. Multi-objective optimization of an energy community: an integrated and dynamic approach for full decarbonisation in the European Alps. International Journal of Sustainable Energy Planning and Management 2023;38:8–29. https://doi.org/10.54337/ijsepm.7607.

[21] Campos J, Munkácsy B. Estimating the potential of residential heat pumps to reduce surplus electricity using the flexible demand tool in EnergyPLAN. International Journal of Sustainable Energy Planning and Management 2024;43. https://doi.org/10.54337/ijsepm.8394.

[22] Østergaard PA, Lund H, Mathiesen B V. Energy system impacts of desalination in Jordan. International Journal of Sustainable Energy Planning and Management 2014;1. https://doi.org/10.5278/ijsepm.2014.1.3.

[23] Askeland K, Rygg BJ, Sperling K. The role of 4th generation district heating (4GDH) in a highly electrified hydropower dominated energy system. International Journal of Sustainable Energy Planning and Management 2020. https://doi.org/10.5278/ijsepm.3683.

[24] Prina MG, Moser D, Vaccaro R, Sparber W. EPLANopt optimization model based on EnergyPLAN applied at regional level: the future competition on excess electricity production from renewables. International Journal of Sustainable Energy Planning and Management 2020;27. https://doi.org/10.5278/ijsepm.3504.

[25] Tamtam F, Tourabi A. Adaptive Planning of Renewable Energy Technologies: A Hybrid Fuzzy Dombi–MAIRCA Framework for Sustainable Energy Management. International Journal of Sustainable Energy Planning and Management 2026;48. https://doi.org/10.54337/ijsepm.10170.

[26] Richter BK, Marcondes GH, al. E. Industrial energy efficiency assessment and prioritization model: An approach based on multi-criteria method PROMETHEE. International Journal of Sustainable Energy Planning and Management 2023;37. https://doi.org/10.54337/ijsepm.7335.

[27] Saleki S. Introducing Multi-Stage Qualification for Micro-Level Decision-Making (MSQMLDM) Method in the Energy Sector – A case study of Photovoltaic and Wind Power in Tehran.

International Journal of Sustainable Energy Planning and Management 2018;17. https://doi.org/10.5278/ijsepm.2018.17.6.

[28] Güleç F, Williams O, Kostas ET, Samson A, Lester E. A comprehensive comparative study on the energy application of chars produced from different biomass feedstocks via hydrothermal conversion, pyrolysis, and torrefaction. Energy Convers Manag 2022;270:116260. https://doi.org/10.1016/j.enconman.2022.116260.

[29] Nugroho HYSH, Et al. Strengthening Micro-hydro Initiatives for Community-Based Sustainable Forest Management. International Journal of Sustainable Energy Planning and Management 2026;48. https://doi.org/10.54337/ijsepm.10497.

[30] Putranto LM. Generation expansion planning for high-potential hydropower resources: The case of the Sulawesi electricity system. International Journal of Sustainable Energy Planning and Management 2020;28:37–52. https://doi.org/10.5278/ijsepm.3247.

[31] Siregar YI. Ranking of energy sources for sustainable electricity generation in Indonesia: A participatory multi-criteria analysis. International Journal of Sustainable Energy Planning and Management 2022;35. https://doi.org/10.54337/ijsepm.7241.

[32] Toukan DO. Scenario modelling of sustainable electricity pathways in Côte d'Ivoire: an open-source system framework. International Journal of Sustainable Energy Planning and Management 2026;48. https://doi.org/10.54337/ijsepm.11265.

[33] Brown T, Hörsch J, Schlachtberger D. PyPSA: Python for power system analysis. J Open Res Softw 2018;6. https://doi.org/10.5334/jors.188.

[34] Hassan MM, Yazawa N, Cong R. Scenario-based framework for national energy storage integration in decarbonization pathways. International Journal of Sustainable Energy Planning and Management 2025;47. https://doi.org/10.54337/ijsepm.10125.

[35] Groissböck M. Energy hub optimization framework based on open-source software & data - review of frameworks and a concept for districts & industrial parks. International Journal of Sustainable Energy Planning and Management 2021;31. https://doi.org/10.5278/ijsepm.6243.

[36] Yuliang J. Evaluating a Blockchain-Enabled Distributed Energy Trading Platform for Rural Electrification: A Case Study in East Shewa, Ethiopia. International Journal of Sustainable Energy Planning and Management 2026;48. https://doi.org/10.54337/ijsepm.10819.

[37] Matak N, et al. Co-Creating Energy Models in Africa: Stakeholder Perspectives from Morocco, Mozambique, and Mali. International Journal of Sustainable Energy Planning and Management 2025;45. https://doi.org/10.54337/ijsepm.10016.