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Solid Biomass Energy Pathways: Feedstock Resources, Conversion Routes, Sustainability Implications, and Deployment Prospects

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ABSTRACT

Solid biomass remains one of the few renewable resources capable of delivering dispatchable energy while also supporting waste valorization and rural economic activity. This review re-examines the role of solid biomass in low-carbon energy systems by synthesizing evidence on feedstock availability, thermochemical conversion routes, environmental performance, and techno-economic feasibility. The discussion covers agricultural residues, forestry by-products, dedicated energy crops, and the organic fraction of municipal waste, emphasizing how calorific value, moisture level, ash content, and logistics shape technology selection. Combustion, pyrolysis, and gasification are compared in terms of operating conditions, conversion efficiency, emissions, and product flexibility, with additional attention to co-benefits such as biochar generation and combined heat and power integration. The review also evaluates life-cycle emissions, policy support, feedstock supply chains, and scale-up barriers that determine whether biomass systems deliver genuine climate benefits or simply shift burdens to land, air quality, and food systems. Across the surveyed literature, the strongest performance is observed when biomass is locally sourced, properly pretreated, and deployed within robust sustainability frameworks. Although solid biomass cannot serve as a universal replacement for fossil fuels, it can make a meaningful contribution to distributed heat and power generation, circular waste management, and regional decarbonization. Continued progress will depend on cleaner conversion technologies, better resource governance, digital process monitoring, and stronger integration with bio-refinery and circular-economy models.

1. Introduction

Rising energy demand, tightening emissions constraints, and the urgency of climate mitigation have renewed interest in renewable resources that can provide more than intermittent electricity. Among these options, biomass remains distinctive because it can be stored, transported, and converted into heat, power, and fuels using several mature and emerging pathways. Within the wider bioenergy portfolio, solid biomass occupies a particularly important position because it is abundant, widely distributed, and technically compatible with both centralized and decentralized energy applications. As a result, solid biomass continues to attract attention not only as a replacement for fossil energy, but also as a practical route for linking waste management, rural development, and decarbonization agendas [1], [2], [3], [4].

The strategic value of solid biomass extends beyond its renewable origin. In many regions, especially in low- and middle-income economies, biomass still underpins household heating and cooking, while in industrialized settings it increasingly serves combined heat and power plants, district heating networks, and co-firing systems. When biomass supply chains are responsibly managed, the resource can strengthen energy security, create local employment, and reduce open burning or landfill disposal of organic residues. These wider system benefits explain why solid biomass is often framed not only as an energy vector, but also as an instrument for resource recovery and regional resilience [1], [4], [5].

The feedstock base for solid biomass is exceptionally diverse and includes wood wastes, forestry residues, crop by-products, municipal organic fractions, and purpose-grown energy crops such as miscanthus and switchgrass. That diversity is valuable, but it also introduces major variability in lower heating value, ash content, moisture level, bulk density, and inorganic composition. These properties directly influence storage behavior, preprocessing requirements, emissions formation, and the choice of conversion technology. At the same time, sustainability concerns such as land-use change, biodiversity pressure, and competition with food or soil restoration functions must be accounted for when evaluating the real contribution of biomass to energy transitions [1], [3], [4], [6].

From a process perspective, solid biomass can be converted through combustion, gasification, and pyrolysis, each of which offers a different balance between simplicity, efficiency, and product flexibility. Combustion is the most established route and remains dominant in direct heat and power applications. Gasification produces a combustible synthesis gas that can be used for electricity, heat, or downstream fuel synthesis, whereas pyrolysis generates bio-oil, syngas, and biochar under oxygen-limited conditions. These pathways differ substantially in reactor design, temperature window, residence time, and tolerance to feedstock variability, which means that process selection must be matched carefully to the intended end use and local operating constraints [1], [4], [7].

The environmental case for solid biomass is therefore conditional rather than automatic. While biomass carbon can in principle be recycled through plant growth, actual climate performance depends on harvesting practices, transportation distances, conversion efficiency, and pollutant control.

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Poorly managed systems may generate significant particulate matter, NOx, SOx, or land-use impacts, whereas optimized systems can reduce fossil dependence and even create carbon-negative outcomes when biochar is sequestered. Against this background, a critical review of feedstocks, technologies, impacts, and deployment conditions is necessary to clarify where solid biomass fits within credible low-carbon energy strategies [8], [9], [6], [10].

To position solid biomass within the wider decarbonization literature, adjacent review and research themes also cover sustainable aviation fuel deployment [11], ammonia production systems [12], aviation-routing efficiency [13], ammonia-hydrogen gas-turbine cycles [14], electrolytic hydrogen pathways [15], CFD-based airflow and contaminant transport [16], numerical modeling of energy systems [17], integrated SAFE pathways [18], catalytic routes for green fuels [19], passive ventilation enhancement in buildings [20], microbiological energy recovery [21], CARSOXY combustion concepts [22], waste-food valorization [1], windcatcher optimization [23], and prior journal-level synthesis on solid biomass [2].

2. Methodology

This review was structured as a targeted synthesis of the scientific and technical literature on solid biomass energy, with the aim of capturing both foundational knowledge and recent developments. Publications were screened from major indexing platforms including Scopus, Web of Science, ScienceDirect, and Google Scholar. The review window covered material published between 2005 and 2025 so that classical references on conversion science could be considered alongside newer work on sustainability assessment, system integration, and digital optimization. Search strings combined terms such as solid biomass energy, biomass combustion, gasification, pyrolysis, biochar, biomass feedstock, life cycle assessment, and biomass policy [2], [3], [4].

Source selection prioritized peer-reviewed journal articles, books, technical reports, and policy documents that provided one or more of the following: feedstock characterization, experimental conversion data, process modeling, environmental assessment, or techno-economic evaluation. Studies were favored when they reported measurable parameters such as temperature range, residence time, product yield, efficiency, moisture sensitivity, or emissions behavior. Geographic diversity was also considered so that the review would reflect how regional resource bases, infrastructure maturity, and policy conditions influence the deployment of biomass systems [8], [9], [5].

The technology review focused on the three principal thermochemical pathways for solid biomass: combustion, pyrolysis, and gasification. For each route, the literature was examined for reactor configuration, typical operating window, efficiency, major outputs, and emission profile. Comparative studies were especially useful because they enabled side-by-side interpretation of how similar feedstocks behave under different processing conditions. Particular attention was given to process variables that govern scale-up performance, including feedstock pretreatment, ash behavior, tar generation, and the handling of co-products such as char and syngas [1], [4], [7].

Economic and policy evidence was reviewed in parallel with the technical literature. This part of the analysis examined cost elements associated with biomass collection, transportation, drying, densification, storage, and conversion, as well as policy instruments such as feed-in tariffs, renewable portfolio standards, subsidy mechanisms, and carbon incentives. Reports from the European Union, the U.S. Department of Energy, and national programs in countries such as India, Brazil, and China were used to identify recurring enablers and constraints affecting biomass commercialization [24], [25], [8], [9].

Life cycle assessment results were compiled to compare the broader environmental implications of solid biomass pathways. Whenever studies used different functional units or system boundaries, the reported outcomes were interpreted with attention to whether they represented cradle-to-gate or cradle-to-grave assumptions. Emissions data for CO2, CH4, NOx, SOx, and particulate matter were extracted where available, and the role of biochar as a carbon sink was considered in cases where pyrolysis systems were evaluated beyond simple energy output. Sensitivity discussions reported in the literature were also used to highlight the main uncertainty drivers [8], [9], [6], [10].

The final synthesis was organized into three core tables covering feedstock properties, conversion performance, and major emission-control approaches. In addition, qualitative evidence from stakeholder surveys, government strategies, industrial reports, and academic outlook studies was incorporated to capture issues that purely technical datasets may overlook, including investment readiness, infrastructure constraints, public acceptance, and future research direction. This combination of quantitative comparison and contextual interpretation was used to build an integrated view of the current status and future trajectory of solid biomass energy systems [17], [24], [8], [5].

This broader frame is useful because energy-transition assessment increasingly draws on neighboring evidence from indoor-air-quality optimization in residences [26], methane-air turbine control [27], alternative-fuel assessments [24], blue-ammonia transition pathways [28], engine-power quantification methods [29], residential windcatcher case studies [30], sustainable aviation fuel reviews [31], CFD analyses of viral aerosol dispersion [32], aviation-route optimization [33], unconventional-cycle parametric studies [34], green-hydrogen overviews [25], pollutant-exposure health assessments [35], biomass pathway-and-constraint reviews [3], humidified gas-turbine configurations [36], and scalable carbon-capture pathways [8].

Table 1. Characteristics of Common Biomass Feedstocks

Feedstock Type	LHV (MJ/kg)	Moisture Content (%)	Ash Content (%)
Wood residues	16.2	20–40	0.5–2.0
Agricultural residues	13.8	10–25	5.0–15.0
Energy crops (e.g., miscanthus)	18.0	12–30	1.0–3.0
Organic municipal waste	9.5	50–70	15.0–25.0

Table 2. Performance Comparison of Biomass Conversion Technologies

Technology	Temperature Range (°C)	Efficiency (%)
Combustion	800–1000	20–35
Pyrolysis	400–600	45–65
Gasification	800–1200	30–50

Table 3. Environmental Emissions and Mitigation Options

Pollutant	Source	Mitigation Strategy	Pollutant
CO$_2$	Combustion, Gasification	Carbon capture, Biochar sequestration	CO$_2$
NO$_x$ & SO$_x$	Combustion residues	Flue gas treatment, Low-NO$_x$ burners	NO$_x$ & SO$_x$
Particulate Matter	Combustion ash	Cyclone filters, Electrostatic precipitators	Particulate Matter

3. Results

The surveyed literature indicates that solid biomass has moved well beyond its traditional role as a low-grade combustion fuel and is now treated as a flexible resource within broader renewable energy systems.

The horizontal comparison in Figure 1(a) shows that agricultural residues account for the largest share of the identified global feedstock base at 46%, followed by municipal solid waste at 28%, while forest residues and dedicated energy crops each contribute 12%. This pattern underscores the strong dependence of biomass energy strategies on agricultural production systems and on the increasing importance of waste-to-energy frameworks in urban environments [1], [2], [4].

The production trend shown in Figure 1(b) reflects a steady rise in biomass-derived energy output from roughly 2.3 EJ in 2000 to about 5.7 EJ in 2020. The trajectory suggests that biomass deployment has expanded through a combination of policy support, improvements in conversion systems, and the gradual integration of biomass into combined heat and power facilities [4], [7].

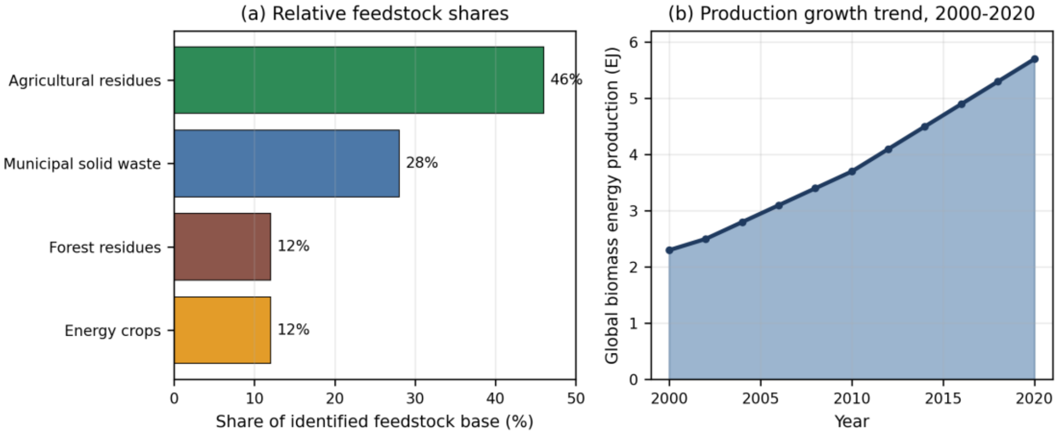

Fig. 1. (a) Horizontal comparison of the relative shares of major solid biomass feedstock classes; (b) area-based trend in global biomass energy production from 2000 to 2020.

Technological results show that combustion continues to dominate commercial deployment because of its relative simplicity and compatibility with established boiler infrastructure. Even so, the literature points to a clear shift toward more advanced gasification and pyrolysis systems where higher product flexibility or cleaner conversion is needed.

Developments in fluidized-bed gasifiers, downdraft units, staged reactors, and oxygen-assisted systems have improved syngas quality and reduced tar-related limitations. In parallel, slow and fast pyrolysis routes have been refined to favor either biochar retention or liquid product generation depending on process objectives [4], [7].

Environmental performance remains strongly technology- and feedstock-dependent. Direct combustion systems are consistently associated with NOx, SOx, and particulate emissions when high-ash or high-moisture fuels are used without sufficient control. The reviewed studies nevertheless show that flue-gas treatment, low-NOx burners, improved reactor design, and better feedstock conditioning can markedly reduce these emissions [5].

Pyrolysis-derived biochar emerges as one of the most significant co-benefits identified in the literature. Beyond its role as a solid carbon-rich by-product, biochar has been linked to improved soil water retention, enhanced cation exchange capacity, and greater microbial activity in degraded soils.

Several life-cycle studies further indicate that biochar-amended systems may offset approximately 2.1 to 3.9 tCO2-equivalent per ton of feedstock under favorable assumptions, making pyrolysis attractive in settings where both energy production and soil management are valued [9], [6].

Economic evidence suggests that direct combustion remains the most competitive pathway in regions with reliable residue streams and basic preprocessing infrastructure. Reported levelized costs of energy commonly fall in the range of 6 to 9 USc/kWh for pellet-based combustion systems, whereas gasification often lies nearer 10 to 15 USc/kWh because of higher capital intensity and tighter operational control requirements [4], [7].

The waffle-chart representation in Figure 2 reinforces the concentration of the biomass resource base in a few dominant categories and makes the minor 2% contribution from other sources more explicit. That visual pattern supports the broader conclusion that feedstock strategy is central to biomass system performance, especially where projects are expected to deliver circular-economy benefits alongside energy output [1], [4].

Policy and governance continue to shape deployment outcomes. Renewable energy mandates, feed-in tariffs, sustainability criteria, and certification frameworks have accelerated biomass uptake in some regions, while seasonal feedstock supply, moisture control, aggregation costs, and quality assurance remain persistent barriers in others [24], [25], [9].

A further result emerging from recent literature is the growing integration of solid biomass with hybrid and digitally enabled systems. Examples include biomass-solar thermal configurations, co-firing strategies, sensor-based combustion control, and machine-learning tools for predictive maintenance. Overall, the evidence positions solid biomass as a versatile but context-dependent contributor to low-carbon energy transitions [17], [8], [9], [4], [5].

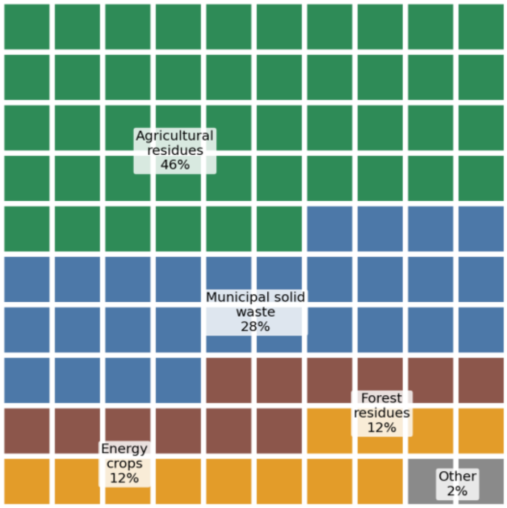

Fig. 2. Waffle-chart representation of global solid biomass feedstock composition, emphasizing the dominance of agricultural residues and the smaller contributions of municipal solid waste, forest residues, energy crops, and other sources.

The comparative interpretation of biomass systems also benefits from adjacent literature on clean-power separation processes [37], turbine-blade behavior under NH3-H2 combustion products [38], optical diagnostics of CARSOXY flames [39], Kalina-cycle heat-recovery optimization [40], power-plant emissions associated with HVAC electricity demand [41], CARSOXY techno-economics [42], office-air-quality enhancement through façade design [43], ammonia-fueled turbine-blade simulations [44], separation-process state-of-the-art reviews [45], sustainable-aviation-fuel pathway updates [46], doctoral-scale CARSOXY system development [47], CO2-emissions quantification for HVAC-linked power demand [48], unattended monitoring and control studies [49], methane satellite-image forecasting [50], and double-skin-façade airflow optimization [51].

4. Discussion

The results confirm that solid biomass should not be treated as a single technology or a uniformly sustainable resource. Instead, it functions as a family of energy pathways whose performance depends on how feedstocks are sourced, conditioned, converted, and governed.

This helps explain why biomass can appear highly beneficial in one setting and much less attractive in another. The same feedstock class may support low-emission heat and power under controlled conditions, yet create air-quality or land-use concerns when handled poorly.

A central implication of the reviewed evidence is that conversion efficiency remains one of the decisive factors separating credible biomass systems from marginal ones. Conventional combustion is easy to deploy and relatively inexpensive, but it often sacrifices efficiency and pollutant control unless paired with modern combustion management and emissions treatment.

Gasification and pyrolysis offer stronger prospects for product diversification and cleaner downstream use, but they demand greater technical sophistication, tighter process control, and often higher up-front investment. The practical choice among these pathways is therefore not purely thermodynamic; it is institutional, economic, and logistical as well.

Feedstock logistics are equally fundamental. Agricultural residues and forestry by-products may appear plentiful in aggregate statistics, yet actual recoverable volumes are constrained by seasonal access, competing uses, collection cost, and the need to leave some residues on the land for soil protection.

This is why preprocessing steps such as drying, pelletization, briquetting, and blending often determine whether a biomass project becomes bankable. The literature consistently shows that resource quality and supply-chain stability matter as much as reactor performance.

The socio-economic dimension adds another layer of complexity. Biomass can create local employment, improve energy access, and reduce dependence on imported fuels, especially in rural and peri-urban regions. However, poorly governed expansion may also intensify land competition, environmental degradation, or unequal benefit distribution.

Biochar-centered systems deserve particular attention because they broaden the meaning of biomass utilization from energy conversion to carbon management and soil restoration. Where biochar improves soil function, retains carbon, and offsets agricultural inputs, the system-level benefit may exceed that of a simple combustion pathway, although these gains remain sensitive to feedstock type and application context.

Policy coherence is another recurring determinant of success. Stable support mechanisms, clear sustainability criteria, and transparent certification systems appear repeatedly in the case studies associated with successful deployment, whereas fragmented regulation can undermine investment and long-term planning.

The discussion also points to a growing role for innovation beyond the reactor itself. Digital monitoring, remote sensing, traceability tools, and AI-assisted optimization are beginning to improve feedstock management, process stability, and maintenance planning, although technology transfer remains essential if these benefits are to extend beyond well-funded pilot programs.

Taken together, the reviewed evidence positions solid biomass as a strategically useful but inherently conditional part of the global energy transition. Future progress will depend on cleaner conversion routes, stronger carbon accounting, better supply-chain design, and deployment models that are locally grounded and socially durable.

The wider systems literature further highlights the importance of integration, as shown by work on carbon-capture materials and process pathways [9], ammonia-plant heat-exchanger integration [52], additional biomass-energy pathway reviews [4], photovoltaic-powered DAC concepts for buildings [53], hydrogen pathway overviews [54], sustainability and market-behavior studies [55], geothermal power prospects [56], electrical control platforms [57], energy-balance improvement in hydrocarbon recovery from microalgal systems [58], and broad clean-air science and policy syntheses [59].

5. Conclusion

This review shows that solid biomass remains an important, though highly context-sensitive, component of sustainable energy systems. Its relevance stems from the breadth of available feedstocks, the maturity of several conversion routes, and its capacity to connect energy production with waste management and rural development.

At the same time, the evidence makes clear that biomass should be judged by actual system performance rather than by renewable status alone.

Feedstock quality and availability form the basis of all viable biomass strategies. Agricultural residues, forestry by-products, municipal organic fractions, and energy crops each offer different opportunities and constraints, while moisture level, ash content, calorific value, seasonality, and competing uses shape how far these resources can be mobilized without compromising sustainability.

Among conversion pathways, combustion remains the most established option, particularly for direct heat and power. Gasification and pyrolysis, however, broaden the value proposition by enabling cleaner gas streams, liquid intermediates, and carbon-rich solid products such as biochar.

The environmental contribution of solid biomass is conditional on lifecycle design. Sustainable sourcing, efficient conversion, and pollutant control are essential if biomass is to reduce greenhouse-gas emissions without creating new burdens for air quality, soils, land use, or biodiversity.

Economic feasibility is similarly dependent on context. Systems based on local residues and straightforward conversion routes can be competitive, whereas higher-performance platforms often require policy support, co-product valorization, or carbon-linked revenue streams to become attractive at scale.

Policy, governance, and social participation ultimately determine whether technical potential becomes durable impact. Biomass programs perform best when energy policy is coordinated with waste, agriculture, forestry, and rural-development agendas and when communities participate meaningfully in supply chains and benefit sharing.

Support for innovation, training, certification, and digital monitoring will further strengthen the sector.

Overall, solid biomass should be seen neither as a universal remedy nor as a marginal legacy fuel. Properly managed, it can operate as a durable pillar of low-carbon heat, power, and circular resource recovery through cleaner conversion technologies, stronger sustainability metrics, and locally grounded deployment models.

References

[1] El-Zein, Fatima Y., and Omar T. Al-Khatib. "Waste Food to Energy: Sustainable Bioenergy Conversion." Energy Conversions (2025).

[2] Hossain, Leila M. "A Review of Solid Biomass Energy." Energy Conversions (2025).

[3] Khalil, Ibrahim Asad, and Matteo DanielRos. "Powering Tomorrow with Biomass: Options and Constraints." Energy Conversions (2025).

[4] Khalil, Ibrahim Asad, and Matteo DanielRos. "Biomass Energy: Pathways, Potentials, and Challenges for a Sustainable Energy Future." Energy Conversions (2025).

[5] El Dayd, Narriam A., Imer J. Garouq, Faniell W. Jarpar, Keena T. Faddaad, and Qei Xhaang. "A Comprehensive Review of Air Quality Science, Measurement, Health Impacts, and Policy Pathways for Clean Air." Energy Conversions (2025).

[6] Al-Assaf, Anwar H., Mohammad Ismail, and Mohamad I. Al-Widyan. "Evaluating Solar Tracking System Efficiency in Dusty and Humid Environments." Energy Conversions (2025).

[7] Asad, Sarah Nurdeen, Ahmed Tamer Fahad, and Lin Jaco Gonzalez. "From Molecules to Megatons: Materials, Process Intensification, and Infrastructure Integration for Scalable CO_2 Capture." Energy Conversions (2025).

[8] Asad, Sarah Nurdeen. "Materials, Processes, and Integration Pathways Toward Scalable Carbon Capture." Energy Conversions (2025).

[9] Asad, Sarah Nurdeen, Ahmed Tamer Fahad, and Lin Jaco Gonzalez. "Advances and Perspectives in Carbon Capture: Materials, Processes, and System Integration for a Low-Carbon Future." Energy Conversions (2025).

[10] Alrebei, O. F., A. I. Amhamed, and H. Muftah. "Evaluating carbon capture scenarios using ammonia-based direct air capture routes." Comput. Aided Chem. Eng 52 (2022): 1409-1414.

[11] Schultz, Hannah T. "Pathways to Net-Zero: Sustainable Aviation Fuel in Action." Energy Conversions (2025).

[12] Amhamed, Abdulkarem I., Syed Shuibul Qarnain, Sally Hewlett, Ahmed Sodiq, Yasser Abdellatif, Rima J. Isaifan, and Odi Fawwaz Alrebei. "Ammonia production plants—a review." Fuels 3, no. 3 (2022): 408-435.

[13] Al-Hashmi, Omar. "Efficient Journeys: The Future of Aviation Routing." Energy Conversions (2025).

[14] Aalrebei, Odi Fawwaz, Anwar Hamdan Al Assaf, Abdulkarem Amhamed, Nedunchezhian Swaminathan, and Sally Hewlett. "Ammonia-hydrogen-air gas turbine cycle and control analyses." International Journal of Hydrogen Energy 47, no. 13 (2022): 8603-8620.

[15] Al-Hussein, Hashim. "Electrolytic Hydrogen for a Decarbonized Future." Energy Conversions (2025).

[16] Alrebi, Odi Fawwaz, Bushra Obeidat, Ibrahim Atef Abdallah, Eman F. Darwish, and Abdulkarem Amhamed. "Airflow dynamics in an emergency department: A CFD simulation study to analyse COVID-19 dispersion." Alexandria Engineering Journal 61, no. 5 (2022): 3435-3445.

[17] Martin, Hogo M. "From Simulation to Application: Advancements in Numerical Modeling of Energy Systems." Energy Conversions (2025).

[18] Amhamed, Abdulkarem I., Anwar Hamdan Al Assaf, Laurent M. Le Page, and Odi Fawwaz Alrebei. "Alternative sustainable aviation fuel and energy (SAFE)-A Review with selected simulation cases of study." Energy Reports 11 (2024): 3317-3344.

[19] Al-nur, Sumia M. "Catalytic Innovation for Green Fuel Production: Progress and Prospects." Energy Conversions (2025).

[20] Fawwaz Alrebei, Odi, Laith M. Obeidat, Shouib Nouh Ma’bdeh, Katerina Kaouri, Tamer Al-Radaideh, and Abdulkarem I. Amhamed. "Window-windcatcher for enhanced thermal comfort, natural ventilation and reduced COVID-19 transmission." Buildings 12, no. 6

(2022): 791.

[21] Sayegh, Lara N., and Enzo D. Martelli. "Advancements in Microbiological Energy." Energy Conversions (2025).

[22] Fawwaz Alrebei, Odi, Ali Al-Doboon, Philip Bowen, and Agustin Valera Medina. "CO2-Argon-Steam Oxy-Fuel production for (CARSOXY) gas turbines." Energies 12, no. 18 (2019): 3580.

[23] Obeidat, Laith M., Odi Fawwaz Alrebei, Shouib Nouh Ma’bdeh, Tamer Al-Radaideh, and Abdulkarem I. Amhamed. "Parametric enhancement of a window-windcatcher for enhanced thermal comfort and natural ventilation." Atmosphere 14, no. 5 (2023): 844.

[24] Qassem, Lina H. "A Comprehensive Review of Alternative Fuels for Power Generation." Energy Conversions (2025).

[25] Mostafa, Layan, and Tariq Al-Hussein. "Green Hydrogen Global Effort." Energy Conversions and Managements 101, no. 1 (2025).

[26] Obeidat, L. M., James R. Jones, D. M. Mahaftha, A. I. Amhamed, and O. F. Alrebei. "Optimizing indoor air quality and energy efficiency in multifamily residences: Advanced passive pipe system parametrics study." International Journal of Environmental Science and Technology 21, no. 16 (2024): 10003-10026.

[27] Alrebei, Odi Fawwaz, Anwar Hamdan Al Assaf, Mohammad S. Al-Kuwari, and Abdulkarem Amhamed. "Lightweight methane-air gas turbine controller and simulator." Energy Conversion and Management: X 15 (2022): 100242.

[28] Alrebei, Odi Fawwaz, Laurent M. Le Page, Gordon Mckay, Muftah H. El-Naas, and Abdulkarem I. Amhamed. "Recalibration of carbon-free NH3/H2 fuel blend process: Qatar's roadmap for blue ammonia." International Journal of Hydrogen Energy 48, no. 61 (2023): 23716-23736.

[29] Farouq, Leena, and Mahmud Khan. "Approaches in Quantifying Engine Power." Energy Conversions (2025).

[30] Nouh Ma’bdeh, Shouib, Odi Fawwaz Alrebei, Laith M. Obeidat, Tamer Al-Radaideh, Katerina Kaouri, and Abdulkarem I. Amhamed. "Quantifying energy reduction and thermal comfort for a residential building ventilated with a window-windcatcher: A case study." Buildings 13, no. 1 (2023): 86.

[31] Langstona, Sarah E., and Hannah T. Schultz. "Sustainable Aviation Fuel." Energy Conversions (2025).

[32] Obeidat, Bushra, Odi Fawwaz Alrebei, Ibrahim Atef Abdallah, Eman F. Darwish, and Abdulkarem Amhamed. "CFD Analyses: The Effect of pressure suction and airflow velocity on coronavirus dispersal." Applied Sciences 11, no. 16 (2021): 7450.

[33] Qureshi, Lina. "Aviation Route Optimization." Energy Conversions (2025).

[34] Alrebei, Odi Fawwaz, Philip Bowen, and Agustin Valera Medina. "Parametric study of various thermodynamic cycles for the use of unconventional blends." Energies 13, no. 18 (2020): 4656.

[35] Taha, Sara Sami, Souha Idoudi, Naval Alhamdan, Riham H. Ibrahim, Riham Surkatti, Abdulkarem Amhamed, and Odi Fawwaz Alrebei. "Comprehensive review of health impacts of the exposure to nitrogen oxides (NOx), carbon dioxide (CO2), and particulate matter (PM)." Journal of Hazardous Materials Advances 19 (2025): 100771.

[36] Hamdan Al Assaf, Anwar, Abdulkarem Amhamed, and Odi Fawwaz Alrebei. "State of the art in humidified gas turbine configurations." Energies 15, no. 24 (2022): 9527.

[37] Alrebei, Odi Fawwaz, Abdulkarem I. Amhamed, and H. Muftah. "El-Naas, Mahmoud Hayajnh, Yasmeen A." Orabi, Ward Fawaz, Ahmad S. Al-Tawaha, and Agustin Valera Medina." State of the art in separation processes for alternative working fluids in clean and efficient power generation." Separations 9 (2022).

[38] Alrebei, Odi Fawwaz, and M. Laurent. "Le Page, Sally Hewlett, Yusuf Bicer, and Abdulkarem Amhamed." Numerical investigation of a first-stage stator turbine blade subjected to NH3–H2/air combustion flue gases."." International Journal of Hydrogen Energy 47 (2022): 33479-33497.

[39] Alrebei, Odi Fawwaz, Abdulkarem I. Amhamed, Syed Mashruk, Phil Bowen, and Agustin Valera Medina. "Planar Laser-Induced Fluorescence and Chemiluminescence Analyses of CO 2-Argon-Steam Oxyfuel (CARSOXY) Combustion." Energies 15, no. 1 (2021): 1-23.

[40] Hussein, Sadeq, Abrar Salaheldin Ahmed, Ibtehal Mohamed Abuzaid, Riham Surkatti, Aiyad Gannan, Abdulkarem Amhamed, and Odi Fawwaz Alrebei. "Fluid dynamics in the Kalina cycle: Optimizing heat recovery for sustainable energy solutions." Case Studies in Thermal Engineering 63 (2024): 105173.

[41] Alrebei, Odi Fawwaz, Bushra Obeidat, Tamer Al-Radaideh, and M. Laurent. "Le Page, Sally Hewlett, Anwar H." Al Assaf, and Abdulkarem I. Amhamed." Quantifying CO2 emissions and energy production from power plants to run HVAC systems in ASHRAE-based buildings." Energies 15.

[42] Alrebei, O. Fawwaz, A. Aldoboon, P. Bowen, and A. Valera-Medina. "Techno-economics of CO2-Argon-Steam Oxy-Fuel (CARSOXY) Gas Turbines." DEStech Transactions on Environment, Energy and Earth Sciences iceee (2019).

[43] Ma’bdeh, Shouib Nouh, Asia Ali Hamasha, Majd Al-Shawabkeh, Razan Omar Alali, Rahaf Mohammad Almomani, Laith M. Obeidat, and Odi Fawwaz Alrebei. "Enhancing office air quality: The role of window to wall ratio with window-wind catchers using CFD analysis." Energy Reports 13 (2025): 1508-1524.

[44] Alrebei, Odi Fawwaz, Laurent M. Le Page, Sally Hewlett, Yusuf Bicer, and Abdulkarem Amhamed. "Numerical investigation of a first-stage stator turbine blade subjected to NH3–H2/air combustion flue gases." International Journal of Hydrogen Energy 47, no. 78 (2022): 33479-33497.

[45] Alrebei, Odi Fawwaz, Abdulkarem I. Amhamed, Muftah H. El-Naas, Mahmoud Hayajnh, Yasmeen A. Orabi, Ward Fawaz, Ahmad S. Al-Tawaha, and Agustin Valera Medina. "State of the art in separation processes for alternative working fluids in clean and efficient power generation." Separations 9, no. 1 (2022): 14.

[46] Alrebei, Odi, and A. Amhamed. "Advances in drop-in sustainable aviation fuels (SAF): Pathways, challenges, and future directions." International Multidisciplinary Scientific GeoConference: SGEM 3, no. 2 (2024): 391-396.

[47] Alrebei, Odi Fawwaz Awad. "Carbon dioxide-argon-steam oxyfuel (CARSOXY) gas turbines." PhD diss., Cardiff University, 2019.

[48] Alrebei, Odi Fawwaz, Bushra Obeidat, Tamer Al-Radaideh, Laurent M. Le Page, Sally Hewlett, Anwar H. Al Assaf, and Abdulkarem I. Amhamed. "Quantifying CO2 emissions and energy production from power plants to run HVAC systems in ASHRAE-based buildings." Energies 15, no. 23 (2022): 8813.

[49] Al-Assaf, Anwar Hamdan, Odi Alrebei, Abdulkarem Amhamed, Mahmoud Adnan Hayajnh, Ward Fawaz, and S. Ahmad. "Al-tawaha." PID power controller to a setpoint of fluid level height in a reservoir for unattended human monitoring."." Int. J. Electr. Electron. Eng. Stud 8 (2021): 1-13.

[50] Elshukri, Fatima, Noor Hussam Abusirriya, Nathan Joseph Braganza, Abdulkarem Amhamed, and Odi Fawwaz Alrebei. "Temporal and spatial pattern analysis and forecasting of methane: Satellite image processing." Ecological Informatics 89 (2025): 103176.

[51] Ma'bdeh, Shouib Nouh, Razan Omar Alali, Majd Al-Shawabkeh, Rahaf Mohammad Almomani, Asia Ali Hamasha, Rania Shannik, and Odi Fawwaz Alrebei. "Optimizing airflow in double-skin facades: Influence of vents design and cavity depth." Cleaner Engineering and Technology 26 (2025): 100980.

[52] Al Assaf, Anwar Hamdan, Abrar Ahmed, Dima Muawiya Mahaftha, Abdulkarem I. Amhamed, Odi Fawwaz Alrebei, and Bilal A. Jarrah. "NH 3-H 2-Working Fluid-based Shell and Tube Heat Exchanger and the H 2 O-to-H 2 O Helical Heat Exchanger: A Novel Integration to Ammonia Production Plants." Jordan Journal of Mechanical & Industrial Engineering 18, no. 2 (2024).

[53] Al Assaf, Anwar Hamdan, Odi Fawwaz Alrebei, and M. Laurent. "Le Page, Luai El-Sabek, Bushra Obeidat, Katerina Kaouri, Hamed Abufares, and Abdulkarem I." Amhamed." Preliminary design and analysis of a photovoltaic-powered direct air capture system for a residential building." Energies 16 (2023).

[54] Vogar, Markcus, Amir El-Sagerd, and Nouran Al-Khalid. "Hydrogen Energy: Pathways, Technologies, and Global Prospects for a Decarbonized Future." Energy Conversions (2025).

[55] Ayasra, Ola, and O. Alrebei. "the Role of E-Marketing in Supporting Tourist Destinations in Jordan “Case Study: Petra.”." European Journal of Hospitality and Tourism Research 9, no. 4 (2021): 43-57.

[56] Karm, Hmeed, Faisal Husam, and Amar N. Saif. "Geothermal Energy: Pathways, Technologies, and Prospects for Sustainable Power Generation." Energy Conversions (2025).

[57] Al Assaf, Anwar H., and Odi Fawwaz Alrebei. "ELECTRICAL UNMANNED GROUND VEHICLE CONTROLLER." International Journal of Electrical and Electronics Engineering Studies 7, no. 1 (2022): 35-46.

[58] Zei, Shen, Motto Rrci, and Aishir Al-Khalidi. "Advances and Challenges in Solar Energy Conversion: Technologies, Integration Pathways, and Future Prospect." Energy Conversions (2025).

[59] Al Assaf, Anwar Hamdan, and Odi Fawaz. "INCREASING THE ENERGY BALANCE OF HYDROCARBON PRODUCTION FROM B. BRAUNII WITH INCLINED SOLID-LIQUID SEPARATION AND EASY HYDROCARBON RECOVERY." Interdisciplinary Journal of Agriculture and Environmental Sciences (IJAES) 9, no. 1 (2022).

[60] Amhamed, Abdulkrem, Odi Fawwaz Alrebei, Mohammad Al-Kuwari, Ahmed Sodiq, and Yasser Abdellatif. "Direct air-co2-captured via ammonia plants." U.S. Patent Application 18/388,971, filed May 16, 2024.

[61] Abdellah, Yasir M., Huda Saleem, Karim Fathi, and Miar Taiseer. "Hybrid Cooling–Desalination Systems for Water–Energy Co-Production: Architectures, Integration Strategies, Performance Metrics, and Research Needs." Energy Conversions (2025).

[62] Amhamed, Abdukarem I., Anwar Hamdan Al Assaf, Odi Fawaz, Mahmoud Adnan Hayajnh, Ward Fawaz, and Ahmad S. Al-Tawaha. "PID Power Controller to a Setpoint of Fluid Level Height in a Reservoir for Unattended Human Monitoring." International Journal of Electrical and Electronics Engineering Studies (2022).

[63] El-Khuteb, Merwen S., Lena Q. Al-Mamouri, Haris J. Whittcon, Noor A. Fareeh, and Kenj T. Arerri. "Organic Rankine Cycle for Low-to-Medium Temperature Heat Recovery: Working Fluids, Architectures, Expanders, Control, and Deployment Pathways." Energy Conversions (2025).

[64] Ma’bdeh, Shouib Nouh, Razan Omar Alali, Majd Al-Shawabkeh, Rahaf Mohammad Almomani, Asia Ali Hamasha, Rania Shannik, and Odi Fawwaz Alrebei. "Cleaner Engineering and Technology."

[65] Alhumaydi, Laila M., Omer K. Eldynn, Priyah R. Narainanan, and Miguell A. Torrez. "Desalination at Scale: Technology Choices, Energy Pathways, and Circular Brine Management for Low-Carbon Water." Energy Conversions (2025).

[66] Ma’bdeh, Shouib Nouh, Asia Ali Hamasha, Majd Al-Shawabkeh, Razan Omar Alali, Rahaf Mohammad Almomani, Laith M. Obeidat, and Odi Fawwaz Alrebei. "Energy Reports."

[67] Schultz, Hannah T. "Toward Net-Zero Flight: Scaling Sustainable Aviation Fuel Pathways and Policy." Energy Conversions (2025).

[68] Al-Radaideh, Tamer, James Jones, Ikhlas O. Rabab'ah, Dima Muawiya Mahaftha, Odi Fawwaz Alrebei, Kambiz Kia, and Abdulkarem Amhamed. "Enhancing Indoor Ventilation and Air Quality Through Strategic Free Flow Path Design in Educational Office Spaces." Available at SSRN 4682738.

[69] Zei, Shen, Motto Rrci, and Aishir Al-Khalidi. "Solar Energy Conversion at Scale: Performance Progress, Integration Strategies, and the Next Technology Frontiers." Energy Conversions (2025).

[70] Surkattia, Riham, Dina Ewis, Muftah H. El-Naas, Odi Fawwaz Alrebei, and Abdulkarem Amhamed. "Sustainable Circular Hydrogen Carriers: A Comprehensive Review of Production, Transportation, and Storage Technologies." Transportation, and Storage Technologies.

[71] Sayegh, Lara N., and Enzo D. Martelli. "Bioelectrochemical and Anaerobic Pathways for Microbial Energy Recovery: Progress, Performance Metrics, and Deployment Challenges." Energy Conversions (2025).

[72] Amhamed, Abdulkarem, Tamer Al-Radaideh, James Jones, Ikhlas O. Rabab'ah, Dima Muawiya Mahaftha, Odi Fawwaz Alrebei, and Kambiz Kia. "Enhancing Indoor Ventilation and Air Quality Through Strategic Free Flow Path Design in Educational Office Spaces." Available at SSRN 4589116.

[73] Langston, Sarah E., and Hannah T. Schultz. "From Blend Limits to Net-Zero Flight: Comparing SAF Pathways, Costs, and the Scale-Up to 2050." Energy Conversions (2025).

[74] Aalrebei, Odi Fawwaz, Anwar Hamdan Al Assaf, Mohammad S. Al-Kuwari, and Abdulkarem Amhamed. "Lightweight Methane-Air Gas Turbine Controller and Simulator."

[75] Fawwaz Alrebei, Odi, Abdulkarem I. Amhamed, Syed Mashruk, Phil Bowen, and Agustin Valera Medina. "Planar laser-induced fluorescence and chemiluminescence analyses of CO2-argon-steam oxyfuel (CARSOXY) combustion." Energies 15, no. 1 (2021): 263.

[76] El-Shamyy, Jaalaa M., and Lareem Y. Solimann. "Built Environment 2050: Integrating Efficiency, Health, and Carbon Neutrality Across Buildings and Cities." Energy Conversions (2025).

[77] Al Assaf, Anwar Hamdan, Odi Fawwaz Alrebei, Laurent M. Le Page, Luai El-Sabek, Bushra Obeidat, Katerina Kaouri, Hamed Abufares, and Abdulkarem I. Amhamed. "Preliminary design and analysis of a photovoltaic-powered direct air capture system for a residential building." Energies 16, no. 14 (2023): 5583.

[78] Haffez, Jazmynn K., and Omer R. Albittar R. Albittar. "Cooling Efficiency in Thermal Systems: Metrics, Drivers, and Pathways to Ultra-Low Energy Cooling." Energy Conversions (2025).

[79] Alrebei, O. F., S. Wang, and X. Chen. "Thermodynamic performance of SAF in CFM56–7B turbofan engines." Energy Conversion and Management X 15 (2024): 100123.

[80] Alhumaydi, Laila M., Omer K. Eldynn, Priyah R. Narainanan, and Miguell A. Torrez. "Desalination in the Anthropocene: Technologies, Energy, Brine Management, and Pathways to Ultra-Low-Carbon Water." Energy Conversions (2025).

[81] Alrebei, O. F., A. Amhamed, M. Al-Kuwari, A. Sodiq, and Y. M. Abdellatif. "Direct air-CO_2-captured via ammonia plants." US Patent Application 18, no. 388,971 (2024).

[82] Surkatti, Riham, Dina Ewis, Maria E. Konnova, Muftah H. El-Naas, Yasser Abdellatif, Odi Fawwaz Alrebei, and Abdulkarem Amhamed. "Comprehensive insights into sustainable circular liquid hydrogen carriers: Analysis of technologies and their role in energy transition." Journal of Environmental Chemical Engineering (2025): 118197.

[83] Xhang, Qeihao, Uuting Vhen, Ningjie Kiu, and Cinyu Eang. "Combustion-to-Work Conversion: A Cross-Platform Review of Thermo-Chemical Pathways, Cycles, and Emerging Low-Carbon Directions." Energy Conversions (2025).

[84] Amhamed, Abdulkrem, Odi Fawwaz Alrebei, Mohammad Al-Kuwari, Ahmed Sodiq, and Yasser Abdellatif. "DIRECT AIR-CO2-CAPTURED VIA AMMONIA PLANTS." (2024).

[85] Yiming, Chen, Li Xuewiin, Waing Heeran, Zhong Rai, and Lie Melan. "Thermal Energy Storage for Flexible, Low-Carbon Energy Systems: Materials, Architectures, Design Metrics, and Deployment Pathways." Energy Conversions (2025).