

## Review Article

# Innovations in Energy Conversion Systems: A Mechanical Engineering Perspective

Gourav Singh

UG Student, CSE, Anurag University, Hyderabad.

## I N F O

**E-mail Id:**

Gouravgs24@gmail.com

**Orcid Id:**

<https://orcid.org/0009-0007-8815-3798>

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## A B S T R A C T

The pursuit of efficient, sustainable, and versatile energy conversion systems is essential for addressing the challenges of climate change, resource depletion, and energy security. In this article, we explore the latest innovations in energy conversion systems from a mechanical engineering perspective. From renewable energy technologies to combustion engines, electrification, thermoelectric generators, and system integration, we delve into cutting-edge advancements reshaping the landscape of energy production, distribution, and utilization. With a focus on integration and optimization strategies, including model-based design, multi-objective optimization, data-driven analytics, energy storage management, hybridization, and lifecycle analysis, we highlight the pivotal role of mechanical engineers in driving progress towards a cleaner, more sustainable energy future. Through collaborative efforts and interdisciplinary research, we envision a future where energy conversion systems seamlessly integrate diverse technologies and energy sources, maximizing performance, efficiency, and environmental sustainability.

**Keywords:** Innovations, Energy Conversion Systems, Mechanical Engineering, Renewable Energy, Combustion Engines

## Introduction

Energy conversion systems are the backbone of modern civilization, facilitating the transformation of various energy forms into usable forms that power our homes, businesses, and industries. From the combustion of fossil fuels to the harnessing of renewable sources such as sunlight and wind, these systems enable the generation of electricity, the propulsion of vehicles, and the heating and cooling of our built environment. In the face of pressing challenges such as climate change, resource depletion, and energy security concerns, the development of innovative energy conversion technologies has become imperative.

Within the realm of mechanical engineering, the quest for more efficient, sustainable, and versatile energy conversion systems is both a challenge and an opportunity. Mechan-

ical engineers are uniquely positioned to drive innovation across a wide range of energy conversion technologies, drawing upon their expertise in thermodynamics, fluid mechanics, heat transfer, materials science, and control systems. Whether it's optimizing the performance of combustion engines, enhancing the efficiency of renewable energy systems, or exploring novel approaches to waste heat recovery, mechanical engineers are at the forefront of shaping the future of energy.

In this article, we will explore the latest advancements in energy conversion systems from a mechanical engineering perspective. From renewable energy technologies to combustion engines, electrification, thermoelectric generators, and system integration, we will delve into the cutting-edge innovations that are reshaping the landscape of energy

production, distribution, and utilization. By examining these innovations and their implications, we can gain insights into the opportunities and challenges facing the field of energy conversion and the pivotal role that mechanical engineers play in driving progress towards a more sustainable and resilient energy future.

## Renewable Energy Systems

Renewable energy systems represent a cornerstone in the global transition towards a sustainable energy future. Mechanical engineers are instrumental in advancing the design, development, and deployment of innovative technologies aimed at harnessing the vast potential of renewable energy sources. Beyond wind and solar energy, there exists a diverse array of renewable resources that hold promise for clean and reliable energy generation.

Hydropower, one of the oldest forms of renewable energy, continues to undergo innovation to maximize its efficiency and minimize environmental impact. Conventional hydropower installations, such as dams and run-of-river systems, are being complemented by innovative designs such as tidal and wave energy converters. These technologies harness the kinetic energy of ocean currents and waves to generate electricity, offering a predictable and constant source of renewable power.

Biomass energy systems utilize organic materials such as agricultural residues, forestry waste, and dedicated energy crops to produce heat, electricity, and biofuels. Mechanical engineers are actively involved in optimizing biomass conversion processes, including combustion, gasification, and anaerobic digestion, to enhance energy efficiency and reduce emissions. Moreover, advancements in biomass co-firing and integrated biorefineries enable the production of bio-based chemicals and materials alongside energy generation, contributing to a more sustainable and circular bioeconomy.

Geothermal energy, derived from the heat stored beneath the Earth's surface, presents another promising avenue for renewable energy development. Mechanical engineers are engaged in the design and optimization of geothermal power plants, including conventional steam-based systems and emerging technologies such as enhanced geothermal systems (EGS) and geothermal heat pumps. By leveraging advanced drilling techniques, reservoir modeling, and heat exchanger designs, engineers aim to unlock the full potential of geothermal resources for clean and reliable electricity generation and heating applications.

In addition to these established renewable energy sources, there is ongoing research and development into emerging technologies such as ocean thermal energy conversion (OTEC), concentrating solar thermal (CST) systems, and microbial fuel cells (MFCs). These innovative approaches

hold the promise of tapping into new sources of renewable energy while addressing challenges related to intermittency, scalability, and environmental impact.

Furthermore, the integration of renewable energy systems into the existing energy infrastructure is a complex but essential task. Mechanical engineers play a critical role in designing and implementing grid-connected renewable energy projects, including the development of smart grid technologies, energy storage solutions, and grid management algorithms. By enabling the seamless integration of variable renewable energy sources such as wind and solar power, engineers help ensure the reliability and stability of the power grid while maximizing the utilization of clean energy resources.

In conclusion, renewable energy systems represent a dynamic and rapidly evolving field within mechanical engineering, driven by the urgent need to mitigate climate change and transition to a sustainable energy future. Through innovation, collaboration, and interdisciplinary research, mechanical engineers continue to push the boundaries of what is possible in renewable energy technology, paving the way for a cleaner, more resilient, and equitable energy system for generations to come.

## Combustion Engines and Alternative Fuels

The evolution of combustion engines and the exploration of alternative fuels represent a dynamic landscape in mechanical engineering. Despite the growing prominence of electric propulsion systems, combustion engines continue to play a significant role in various sectors, driving ongoing innovation in pursuit of greater efficiency, performance, and environmental sustainability.

One notable area of advancement is the optimization of engine combustion processes. Engine design, fuel injection systems, and combustion chamber configurations are continually refined to achieve higher thermal efficiency and lower emissions. Direct injection systems, for instance, enable precise control over fuel delivery, improving combustion efficiency and reducing fuel consumption. Additionally, innovations in turbocharging and variable valve timing enhance engine performance across a wide range of operating conditions, striking a balance between power output and fuel efficiency.

Moreover, advancements in combustion modeling and simulation facilitate the development of virtual engine prototypes, accelerating the design iteration process and reducing time-to-market for new engine technologies. Computational fluid dynamics (CFD) simulations allow engineers to analyze complex flow phenomena within the engine cylinder, optimizing combustion processes and minimizing energy losses.

Alternative fuels play a crucial role in reducing the environmental impact of combustion engines and mitigating dependence on fossil fuels. Biofuels derived from renewable sources offer a promising avenue for sustainable energy production. Ethanol, produced from crops such as corn, sugarcane, and switchgrass, is widely used as a gasoline substitute in blends such as E10 (10% ethanol, 90% gasoline) and E85 (85% ethanol, 15% gasoline). Biodiesel, derived from vegetable oils or animal fats, serves as a renewable alternative to petroleum diesel, offering comparable performance and reduced greenhouse gas emissions.

Furthermore, emerging biofuel technologies, such as cellulosic ethanol and algae-based biofuels, hold the potential to further expand the availability of renewable fuels while minimizing competition with food crops and land use. Cellulosic ethanol, produced from non-food biomass sources like agricultural residues and forestry waste, offers a sustainable pathway to ethanol production without competing with food production. Algae-based biofuels, cultivated using sunlight and carbon dioxide, demonstrate high productivity potential and can be grown in non-arable land, providing a scalable solution for renewable fuel production.

In addition to biofuels, synthetic fuels synthesized from renewable resources offer a promising alternative to conventional fossil fuels. Fischer-Tropsch synthesis, for example, converts biomass-derived syngas into liquid hydrocarbons suitable for use in existing combustion engines and fuel infrastructure. Synthetic fuels, characterized by their high energy density and compatibility with existing engine technology, offer a viable transition pathway towards a carbon-neutral transportation sector.

Hydrogen presents another intriguing option as a clean alternative fuel for combustion engines. Hydrogen combustion engines, utilizing hydrogen as the primary fuel source, emit only water vapor as a byproduct, offering zero-emission propulsion. Mechanical engineers are exploring hydrogen combustion engine designs, optimizing combustion processes and addressing challenges related to hydrogen storage, distribution, and infrastructure. Furthermore, hydrogen can be produced through renewable sources via electrolysis, utilizing excess renewable energy to generate hydrogen through water electrolysis, thus facilitating the integration of renewable energy sources with hydrogen-based transportation systems.

In conclusion, the realm of combustion engines and alternative fuels is marked by continuous innovation and exploration, driven by the imperatives of energy security, environmental sustainability, and technological advancement. From optimizing combustion processes and engine design to harnessing renewable fuels and exploring hydrogen as a clean energy carrier, mechanical engineers play a pivotal role in shaping the future of transportation and

power generation. As we navigate towards a low-carbon energy future, the convergence of combustion engine technology and alternative fuels holds immense potential in mitigating climate change and fostering a sustainable energy ecosystem.

## Electrification and Hybridization

Electrification and hybridization represent transformative trends in the realm of energy conversion systems, particularly in transportation and industrial sectors. Mechanical engineers are spearheading innovations in electric propulsion systems, hybrid powertrains, and energy storage technologies to drive the transition towards cleaner, more efficient modes of transportation and machinery operation.

One of the key areas of focus within electrification is the development of high-performance electric motors. Permanent magnet synchronous motors (PMSMs), brushless DC motors (BLDC), and induction motors are among the most commonly used electric propulsion systems in various applications. Mechanical engineers are continuously refining motor designs to improve power density, efficiency, and reliability while reducing size, weight, and cost. Advanced motor control algorithms, such as field-oriented control (FOC) and direct torque control (DTC), enable precise control of electric motors, optimizing performance across a wide range of operating conditions.

In addition to electric motors, advancements in power electronics are essential for the efficient operation of electrified systems. Silicon carbide (SiC) and gallium nitride (GaN) semiconductor devices offer higher switching frequencies, lower losses, and higher temperature capabilities compared to traditional silicon-based devices, enabling the development of more compact and efficient power converters and inverters. Moreover, innovative packaging techniques, such as integrated power modules and multi-level converter topologies, enhance the power density and thermal management of power electronic systems, enabling higher efficiency and reliability.

Energy storage is another critical component of electrified systems, enabling the capture, storage, and utilization of electrical energy. Lithium-ion batteries are the predominant energy storage technology in electric vehicles (EVs) and hybrid electric vehicles (HEVs), offering high energy density, fast charging capabilities, and long cycle life. Mechanical engineers are actively engaged in improving battery performance through innovations in electrode materials, cell chemistry, and battery management systems (BMS). Additionally, research efforts are underway to develop next-generation battery technologies, such as solid-state batteries and lithium-sulfur batteries, with the potential to offer higher energy density, improved safety, and lower cost.

Hybridization represents a complementary approach to electrification, combining the benefits of internal combustion engines with electric propulsion systems. Hybrid powertrains utilize a combination of conventional engines, electric motors, and energy storage systems to optimize fuel efficiency, reduce emissions, and enhance vehicle performance. Mechanical engineers play a pivotal role in designing and optimizing hybrid powertrains, leveraging their expertise in system integration, control theory, and thermal management.

There are several types of hybrid powertrains, each offering unique advantages depending on the application and operating conditions. Parallel hybrids, such as Toyota's Hybrid Synergy Drive, use both the internal combustion engine and electric motor to drive the vehicle, with power flow controlled by a sophisticated hybrid control unit. Series hybrids, like the Chevrolet Volt, rely primarily on the electric motor for propulsion, with the internal combustion engine serving as a generator to recharge the battery or provide supplemental power when needed. Additionally, plug-in hybrid electric vehicles (PHEVs) offer the flexibility of charging the battery from an external power source, enabling extended all-electric driving range and reducing reliance on fossil fuels.

Hybridization is not limited to light-duty vehicles but extends to heavy-duty applications, such as trucks, buses, and construction equipment. Hybrid powertrains for heavy-duty vehicles often incorporate regenerative braking systems to capture and store energy during deceleration, further improving overall energy efficiency. Mechanical engineers are continuously innovating in this space, exploring novel hybrid architectures, optimizing component sizing and placement, and developing advanced control strategies to maximize fuel savings and emissions reductions.

In conclusion, electrification and hybridization represent two complementary approaches to improving energy efficiency, reducing emissions, and enhancing performance across various transportation and industrial applications. Mechanical engineers are driving innovation in electric propulsion systems, power electronics, energy storage technologies, and hybrid powertrains, paving the way towards a cleaner, more sustainable future. As these technologies continue to evolve and mature, the role of mechanical engineering in advancing energy conversion systems will remain indispensable in addressing the challenges of climate change and environmental sustainability.

### **Thermoelectric Energy Conversion**

Thermoelectric energy conversion holds great promise as a clean and efficient method for harnessing waste heat and converting it into usable electricity. This technology relies on the Seebeck effect, where a temperature gradient across

a thermoelectric material generates an electric voltage, allowing for direct conversion of heat into electrical power. Mechanical engineers are at the forefront of advancing thermoelectric energy conversion systems, exploring novel materials, optimizing device architectures, and enhancing system integration for a wide range of applications.

One of the key challenges in thermoelectric energy conversion is improving the efficiency of thermoelectric materials. Traditional materials, such as bismuth telluride and lead chalcogenides, exhibit relatively low conversion efficiencies, limiting the widespread adoption of thermoelectric generators (TEGs). However, recent advancements in materials science, particularly in nanotechnology and solid-state physics, have led to the development of novel thermoelectric materials with significantly enhanced performance.

Nanotechnology-enabled thermoelectric materials represent a significant breakthrough in this regard. By manipulating the size, shape, and composition of materials at the nanoscale, researchers have been able to enhance the thermoelectric properties, such as the Seebeck coefficient and electrical conductivity, while simultaneously reducing thermal conductivity. This results in materials with higher thermoelectric figure of merit (ZT), which dictates the efficiency of thermoelectric energy conversion.

Furthermore, the integration of nanostructures, such as quantum dots, nanowires, and thin films, into thermoelectric devices allows for precise engineering of the electronic band structure and phonon scattering mechanisms, leading to unprecedented improvements in thermoelectric performance. These nanostructured materials exhibit enhanced power factor and reduced thermal conductivity, resulting in higher ZT values and improved overall efficiency of thermoelectric generators.

In addition to materials innovation, advancements in device design and engineering are essential for maximizing the performance of thermoelectric energy conversion systems. Novel device architectures, such as segmented and cascaded thermoelectric modules, enable better management of heat flux and temperature gradients, leading to higher power output and efficiency. Moreover, innovative packaging techniques, such as microchannel heat exchangers and thermally conductive composites, facilitate efficient heat transfer between the heat source and thermoelectric modules, optimizing system performance.

System integration is another critical aspect of advancing thermoelectric energy conversion technology. Mechanical engineers are tasked with designing and optimizing the overall system architecture, including heat exchangers, thermal management systems, and power electronics, to ensure seamless integration and efficient operation of thermoelectric generators in various applications. Advanced



control algorithms and predictive maintenance strategies are employed to monitor system performance and optimize operating conditions in real-time, maximizing energy harvest and reliability.

Thermoelectric energy conversion has diverse applications across various industries, including automotive, aerospace, manufacturing, and power generation. In automotive exhaust systems, thermoelectric generators can recover waste heat from the engine exhaust and convert it into electricity to power onboard electronics or recharge the vehicle's battery, improving fuel efficiency and reducing emissions. In aerospace applications, thermoelectric generators can harness waste heat from aircraft engines or auxiliary power units to supplement onboard power generation, enhancing overall energy efficiency and reliability.

Moreover, thermoelectric energy conversion systems find applications in industrial processes, such as steel-making, glass manufacturing, and chemical processing, where high-temperature waste heat streams are abundant. By capturing and converting waste heat into electricity, thermoelectric generators can help industries reduce energy consumption, lower operating costs, and mitigate environmental impact.

In the realm of power generation, thermoelectric energy conversion offers a distributed and decentralized approach to energy harvesting, suitable for remote or off-grid locations where traditional power infrastructure is unavailable or impractical. By harnessing waste heat from industrial processes, geothermal sources, or solar thermal collectors, thermoelectric generators can provide reliable and sustainable electricity generation, contributing to energy security and resilience.

Looking ahead, the continued collaboration between materials scientists, mechanical engineers, and other interdisciplinary researchers is essential for driving further innovation and commercialization of thermoelectric energy conversion technology. With ongoing advancements in materials synthesis, device fabrication, and system integration, thermoelectric generators have the potential to play a significant role in the transition towards a more sustainable and energy-efficient future.

### Integration and Optimization

In the pursuit of efficient and sustainable energy conversion systems, the integration and optimization of various components and subsystems play a crucial role. Mechanical engineers are tasked with the complex challenge of harmonizing diverse technologies, energy sources, and operational parameters to achieve optimal performance, reliability, and environmental sustainability. This section delves deeper into the strategies and methodologies employed in the integration and optimization of energy conversion systems.

- 1. Model-Based Design and Control:** Model-based design approaches, rooted in mathematical modeling and simulation, offer valuable insights into the behavior and performance of energy conversion systems. By developing detailed models of individual components and the overall system, mechanical engineers can analyze system dynamics, predict performance under different operating conditions, and identify opportunities for improvement. Model predictive control (MPC) techniques leverage these models to optimize system operation in real-time, adjusting control parameters to maximize efficiency, minimize emissions, and ensure system stability.
- 2. Multi-Objective Optimization:** Energy conversion systems often entail trade-offs between conflicting objectives, such as maximizing efficiency while minimizing emissions or operating costs. Multi-objective optimization techniques, such as genetic algorithms, particle swarm optimization, and Pareto optimization, enable engineers to explore the trade-off space and identify solutions that represent the best compromise among competing objectives. These optimization approaches empower decision-makers to make informed choices and design energy conversion systems that strike a balance between performance, environmental impact, and economic viability.
- 3. Data-Driven Analytics:** The proliferation of sensors, actuators, and data acquisition systems in energy conversion systems has paved the way for data-driven analytics and predictive maintenance strategies. By collecting and analyzing operational data, mechanical engineers can identify patterns, anomalies, and potential failure modes, enabling proactive maintenance interventions to prevent unplanned downtime and optimize system reliability. Machine learning algorithms, including supervised learning, unsupervised learning, and reinforcement learning, facilitate the extraction of actionable insights from large volumes of data, empowering engineers to enhance system performance and efficiency iteratively.
- 4. Energy Storage and Management:** Effective energy storage and management are essential components of integrated energy conversion systems, enabling the efficient utilization of renewable energy sources, load balancing, and grid stabilization. Mechanical engineers are involved in the design and optimization of energy storage systems, including batteries, flywheels, compressed air energy storage (CAES), and pumped hydro storage. By optimizing the sizing, operation, and control of energy storage assets, engineers can maximize the utilization of renewable energy, minimize grid instability, and enhance system resilience against

fluctuations in demand and supply.

5. **Hybrid Energy Systems:** Hybrid energy systems, combining multiple energy sources and conversion technologies, offer synergistic benefits in terms of flexibility, reliability, and efficiency. Mechanical engineers are tasked with designing and optimizing the integration of renewable energy sources, such as solar and wind, with conventional energy sources, such as natural gas or diesel generators, in hybrid energy systems. Advanced control strategies, energy management algorithms, and power electronics enable seamless coordination and optimization of diverse energy sources, ensuring reliable and cost-effective operation under varying conditions.
6. **Lifecycle Analysis and Sustainability:** A holistic approach to the integration and optimization of energy conversion systems requires consideration of the entire lifecycle, from design and manufacturing to operation and decommissioning. Lifecycle analysis tools, such as life cycle assessment (LCA) and environmental impact assessment (EIA), enable engineers to quantify the environmental footprint of energy conversion systems and identify opportunities for improvement. By optimizing material selection, manufacturing processes, and end-of-life disposal strategies, mechanical engineers can enhance the sustainability and circularity of energy conversion systems, minimizing resource consumption and environmental impact throughout their lifecycle.

Integration and optimization lie at the heart of innovative energy conversion systems, enabling the seamless integration of diverse technologies and energy sources to achieve maximum performance, efficiency, and sustainability. Through model-based design, multi-objective optimization, data-driven analytics, energy storage management, hybridization, and lifecycle analysis, mechanical engineers are driving advancements in energy conversion systems, paving the way towards a cleaner, more sustainable energy future. As the global energy landscape continues to evolve, the role of mechanical engineering in integrating and optimizing energy conversion systems will remain indispensable in addressing the challenges of climate change, resource scarcity, and energy security.

## Conclusion

Innovations in energy conversion systems have always been crucial for the advancement of modern civilization, enabling the efficient transformation of various energy forms into usable and sustainable sources. From the combustion of fossil fuels to the harnessing of renewable resources like wind and solar power, the evolution of energy conversion technologies has been pivotal in meeting the energy de-

mands of society while mitigating environmental impacts.

Mechanical engineering, with its interdisciplinary approach and expertise in thermodynamics, fluid mechanics, materials science, and control systems, stands at the forefront of driving innovation in energy conversion systems. The quest for more efficient, sustainable, and versatile energy technologies presents both challenges and opportunities for mechanical engineers to explore novel solutions and push the boundaries of what is achievable.

Renewable energy systems, characterized by continuous advancements in wind, solar, hydro, biomass, and geothermal technologies, offer promise for a cleaner and more sustainable energy future. The integration of renewable energy sources into the existing infrastructure, coupled with innovative grid management strategies, enhances energy resilience and reduces reliance on fossil fuels.

In parallel, the evolution of combustion engines and the exploration of alternative fuels underscore the importance of transitioning towards cleaner and more efficient propulsion systems. Mechanical engineers play a crucial role in optimizing combustion processes, developing advanced engine designs, and exploring renewable fuel alternatives to reduce emissions and enhance energy efficiency.

Electrification and hybridization represent transformative trends in transportation and industrial sectors, with mechanical engineers driving innovations in electric propulsion systems, power electronics, and hybrid powertrains. These technologies offer opportunities to reduce dependence on fossil fuels, minimize greenhouse gas emissions, and improve overall energy efficiency.

Thermoelectric energy conversion, although still in its nascent stages, holds great promise for harnessing waste heat and converting it into usable electricity. Through advancements in materials science, device design, and system integration, mechanical engineers are unlocking new opportunities for energy harvesting and efficiency improvement across various applications.

Integration and optimization are central to the advancement of energy conversion systems, enabling the seamless coordination of diverse technologies, energy sources, and operational parameters. By employing model-based design, multi-objective optimization, data-driven analytics, and lifecycle analysis, mechanical engineers can maximize the performance, reliability, and sustainability of energy conversion systems.

As we navigate towards a cleaner, more sustainable energy future, the contributions of mechanical engineering in driving innovation and optimization in energy conversion systems will be paramount. Through collaboration, research, and technological advancements, mechanical engineers are poised to address the challenges of climate

change, resource depletion, and energy security, paving the way towards a brighter and more sustainable future for generations to come.

## References

1. Bošnjaković M, Katinić M, Santa R, Marić D. Wind turbine technology trends. *Applied Sciences*. 2022 Aug 29;12(17):8653.
2. Raugei M, Fullana-i-Palmer P, Fthenakis V. The energy return on energy investment (EROI) of photovoltaics: Methodology and comparisons with fossil fuel life cycles. *Energy policy*. 2012 Jun 1;45:576-82.
3. Lund H, Mathiesen BV. Energy system analysis of 100% renewable energy systems—The case of Denmark in years 2030 and 2050. *Energy*. 2009 May 1;34(5):524-31.
4. Zhang HL, Baeyens J, Degreè J, Cacères G. Concentrated solar power plants: Review and design methodology. *Renewable and sustainable energy reviews*. 2013 Jun 1;22:466-81.
5. Gupta HN. *Fundamentals of internal combustion engines*. PHI Learning Pvt. Ltd.; 2012 Dec 10.
6. Zhao F, Asmus TN, Assanis DN, Dec JE, Eng JA, Najt PM. Homogeneous charge compression ignition (HCCI) engines.
7. Hannon M, Gimpel J, Tran M, Rasala B, Mayfield S. Biofuels from algae: challenges and potential. *Biofuels*. 2010 Sep 1;1(5):763-84.
8. Westbrook CK. Chemical kinetics of hydrocarbon ignition in practical combustion systems. *Proceedings of the combustion institute*. 2000 Jan 1;28(2):1563-77.
9. Vermesan O, Sans M, Hank P, Farrall G, Packer J, Cesario N, Gall H, Blystad LC, Sciolla M, Harrar A. Advanced electronic architecture design for next electric vehicle generation. In *Electric Vehicle Systems Architecture and Standardization Needs: Reports of the PPP European Green Vehicles Initiative 2015* (pp. 117-141). Springer International Publishing.
10. Kumar L, Jain S. Electric propulsion system for electric vehicular technology: A review. *Renewable and Sustainable Energy Reviews*. 2014 Jan 1;29:924-40.
11. Yang C, Zha M, Wang W, Liu K, Xiang C. Efficient energy management strategy for hybrid electric vehicles/plug-in hybrid electric vehicles: review and recent advances under intelligent transportation system. *IET Intelligent Transport Systems*. 2020 Jul;14(7):702-11.
12. Sciarretta A, Guzzella L. Control of hybrid electric vehicles. *IEEE control systems magazine*. 2007 Mar 26;27(2):60-70.
13. Rowe DM, editor. *CRC handbook of thermoelectrics*. CRC press; 2018 Dec 7.
14. Heremans JP, Jovovic V, Toberer ES, Saramat A, Kurosaki K, Charoenphakdee A, Yamanaka S, Snyder GJ. Enhancement of thermoelectric efficiency in PbTe by distortion of the electronic density of states. *Science*. 2008 Jul 25;321(5888):554-7.
15. Cohen I, Kaller M, Komisarchik G, Fuks D, Gelbstein Y. Enhancement of the thermoelectric properties of n-type PbTe by Na and Cl co-doping. *Journal of Materials Chemistry C*. 2015;3(37):9559-64.
16. Zebarjadi M, Esfarjani K, Dresselhaus MS, Ren ZF, Chen G. Perspectives on thermoelectrics: from fundamentals to device applications. *Energy & Environmental Science*. 2012;5(1):5147-62.
17. Rao SS. *Engineering optimization: theory and practice*. John Wiley & Sons; 2019 Nov 12.
18. MacKay DJ. *Sustainable Energy-without the hot air*. Bloomsbury Publishing; 2016 May 14.
19. Cengel YA, Boles MA, Kanoğlu M. *Thermodynamics: an engineering approach*. New York: McGraw-hill; 2011.
20. Ahmed HE, Salman BH, Kherbeet AS, Ahmed MI. Optimization of thermal design of heat sinks: A review. *International Journal of Heat and Mass Transfer*. 2018 Mar 1;118:129-53.