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Theme:

Innovative Engineering Solutions for Viksit Bharat @ 2047




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The Institution of Engineers (India)
8 Gokhale Road, Kolkata 700020

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grid power- resulting environmental pollution and high operating cost.

The paper proposes to focus on Vapour Absorption Refrigeration (VAR) for cooling applications –which is mostly thermal energy driven system. Only for auxiliary drives e.g. pumps/ fans are operated by grid power. Following are the proposed sustainable options for cooling applications:

1. Adopt steam/hot water generation by WHRB or carbon neutral fuel boilers or CST with /without TES to cater thermal energy required for such VAR cooling.
2. For moderate temperature cooling(above zero°C temperature) applications adopt VAR with Li.Br.- Water combination with single/double effect absorption chillers. With such adoption- there will be almost zero need for fossil fuel and demand for grid power will reduce around 85% as compared to VCR cooling. Thus, it will assure sustainable cooling with negligible pollution and very low operating cost.
3. For lower temperature cooling applications (sub-zero temperature) adopt – VAR cooling with ammonia – water combinations. This eliminates problem of freezing of Li.Br. solution at lower temperature. Such cooling applications -will have all the above-mentioned benefits.
4. For additional extension of such cooling -adoption of PV solar power for auxiliary drives like pumps & fans. Thus, in such cases; it will be 100% free of grid electric power & fossil fuels - with almost zero operating cost.

The main paper provides case studies in India - where such aforesaid – heating/cooling applications are already implemented and benefits are well established.

The paper also touched upon adoption of latest sustainable options to be followed in transport sector across India; as presently there is huge vehicular pollutions through petroleum based fossil fuels and rapid increase in such fossil fuel imports.

Additional two completely new innovative & sustainable thermal energy use proposed by the author - for heating / cooling applications; which are so far not adopted or well-known across India. These are for special cases- where only cooling and both heating & cooling simultaneous applications. Techno-economic details / comparison -with respect to presently adopted defaults cases for such applications - with benefits of proposed cases are provided in the paper.

KEYWORDS

Green House Gas (GHG); Concentrated Solar Thermal (CST); Thermal Energy Storage (TES); Waste Heat Recovery Boiler (WHRB); Vapor Absorption Refrigeration (VAR); Vapor Compression Refrigeration (VCR); Photo Voltaic (PV) Solar; Global Warming Potential (GWP); Direct Normal Irradiance (DNI)

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Enhancing Sustainability in Hybrid Vehicles through Solar Power Generation: A Review

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ABSTRACT

The integration of solar power generation in hybrid vehicles offers a promising solution for reducing greenhouse gas emissions and dependence on fossil fuels. By harnessing solar energy, hybrid vehicles can supplement their electric power, decrease reliance on grid charging, and lower overall energy consumption. This study explores the benefits and challenges of solar-powered hybrid vehicles, including reduced emissions, improved fuel efficiency, and increased energy independence. Current solar panel technology, energy storage systems, and powertrain configurations enable efficient solar power utilization. The advantages of solar-powered hybrid vehicles include lower operating costs, reduced carbon footprint, and enhanced sustainability. However, challenges like limited solar panel surface area, energy storage constraints, and high upfront costs exist. Despite these challenges, solar-powered hybrid vehicles are an attractive option for sustainable mobility. As demand for eco-friendly transportation grows, their development is expected to play a significant role in reducing fossil fuel reliance and mitigating climate change. This study provides insights into the current state of solar-powered hybrid vehicles and their potential to contribute to a sustainable transportation future. By exploring opportunities and challenges, new possibilities may be unlocked for environmentally friendly transportation solutions. Solar-powered hybrid vehicles represent a promising step towards a more sustainable transportation sector.

KEYWORDS

Solar Power; Hybrid Vehicles; Sustainability, Renewable Energy; Emissions Reduction

BACKGROUND AND MOTIVATION

The transportation segment is one of the largest suppliers to carbon dioxide emissions globally, responsible for about 27% of energy-related emissions. Most of this effect comes from vehicles powered by internal combustion engines, which are a significant factor in climate change and air pollution. Hybrid vehicles have assisted make transportation more sustainable by combining standard engines with electric drives. However, these vehicles usually depend on either plugging into the electrical grid or using regenerative braking to recharge their batteries. Incorporating photovoltaic (PV) solar panels into hybrid vehicles is a promising innovation that can boost energy efficiency even further. With this technology, vehicles could cut greenhouse gas emissions more and depend less on electricity from the grid, paving the way toward real energy independence.

OBJECTIVES AND SCOPE

This research explores whether solar power systems can be effectively added to hybrid vehicles by evaluating their technical practicality, environmental impact, and potential for cost savings. The study focuses on how solar energy can work in tandem with hybrid vehicle powertrains to improve energy use and support sustainability goals. The analysis covers the types of solar panels currently available for automotive use, the energy storage and power management solutions needed, and different hybrid vehicle designs that can best utilize solar power.

KEY TECHNICAL CONSIDERATIONS

a) **Solar Panel Technology and Integration**

Modern automotive solar panels commonly use monocrystalline or polycrystalline silicon, with efficiencies typically between 15% and 22%. Advances in thin-film photovoltaic materials and multi-junction cells have further enhanced these rates. Solar panels are placed strategically on vehicle surfaces such as the bonnet, roof and rear hatch to maximize sunlight capture while preserving aerodynamic efficiency. Flexible, lightweight solar modules allow these panels to seamlessly integrate into vehicle designs without adding substantial weight or compromising structural strength, making solar power a practical and efficient addition to hybrid vehicles.

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