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Empowering Dairy Farming Through Renewable Energy: A Sustainable Revolution

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Dairy farming has long served as the backbone of rural economies, especially in developing countries like India. This sector is intricately tied to the livelihood of millions and contributes significantly to national food security and economic resilience. However, dairy farming is not without its challenges. A major challenge currently confronting the dairy industry is its significant reliance on traditional energy sources. Electricity and diesel are commonly used for milk chilling, heating, water pumping, lighting, and operating machines, all of which incur significant costs and contribute to environmental degradation.

With the global shift towards sustainable development and green technology, renewable energy has emerged as a vital solution for mitigating the adverse impacts of fossil fuel usage in agriculture. Renewable energy sources—including solar, wind, biogas, and geothermal—are not only environmentally friendly but also economically beneficial over the long run. They offer energy security, reduce greenhouse gas (GHG) emissions, and empower rural communities through decentralized energy systems.

This comprehensive article delves into the multifaceted applications of renewable energy in dairy farming. It highlights successful case studies, innovations, and policy initiatives that are driving this energy transition. The goal is to present an informative and actionable narrative that encourages broader adoption of clean energy technologies in the dairy sector, aligning with national goals and international commitments such as the Paris Agreement and the Sustainable Development Goals (SDGs).

Understanding Renewable Energy and Its Importance

Renewable energy refers to energy derived from natural processes that are replenished constantly. This includes solar radiation, wind, geothermal heat, biomass, and hydropower. Unlike fossil fuels, these sources are inexhaustible in the context of human timescales and emit little to no greenhouse gases during operation. The benefits of renewable energy are numerous. Renewable energy offers a dependable power source, particularly in rural regions where access to the electricity grid is either unreliable or unavailable. Additionally, it offers a pathway to reduce carbon emissions, conserve natural resources, and create green jobs.

India has recognized the immense potential of renewable energy and has taken ambitious steps in this direction. The Ministry of New and Renewable Energy (MNRE) serves as the nodal agency for promoting clean energy. As per the International Renewable Energy Agency (IRENA, 2024), India ranks fourth globally in installed renewable energy capacity. The country has set an ambitious target of achieving 500 GW of non-fossil fuel electricity capacity by 2030. This national momentum has opened avenues for integrating renewable technologies into various sectors, including agriculture and dairy farming. Combining renewable energy with dairy operations can

greatly enhance energy efficiency, reduce operational expenses, and support long-term sustainable milk production.

Geothermal Energy: Harnessing Earth's Natural Heat

Geothermal energy, a relatively untapped resource in India, offers immense promise for dairy farming. It utilizes the natural heat stored within the Earth's crust, which is manifested on the surface through hot springs and geysers. This energy source is available 24/7 and is independent of weather conditions, making it a highly reliable option.

One of the most successful applications of geothermal energy in the dairy sector comes from the Livestock Research Centre (LRC) at the National Dairy Research Institute (NDRI), Karnal. Researchers developed a cost-effective and practical system using a 12-meter deep bore and a 4 cm diameter underground pipe. This system moderated the ambient temperature within animal sheds, increasing warmth by up to 14.4°C in winter and cooling the air by up to 9.5°C in summer. These temperature adjustments significantly reduced animal stress, improved comfort, and enhanced milk production.

In Navsari, Gujarat, a unique system utilized geothermal water for milk pasteurization. The system, designed by Bist et al. (2022), achieved milk heating through natural geothermal flow, reducing microbial load from 69,000 to 28,000 cfu/ml while staying within WHO guidelines. The system proved to be not only sustainable but also cost-effective for rural dairy units.

Biogas: Turning Waste into Wealth

Biogas is a versatile, eco-friendly, and cost-effective form of renewable energy that can play a transformative role in dairy farming. Produced through the anaerobic digestion of organic matter like animal dung, agricultural residues, and food waste, biogas provides a reliable energy source while also addressing the environmental burden of waste disposal.

Biogas Bottling Plants

The Biogas Development and Training Centre (BDTC) at IIT Delhi has developed a system for upgrading and bottling biogas. The process involves high-pressure compressors, storage cylinders, and dispensing nozzles to fill purified gas into vehicles. This innovation enables the use of biogas as a fuel for cooking and transportation, particularly in remote and rural settings.

A single biogas bottling plant can replace around ₹9 lakh worth of fossil fuel annually. Such systems can be implemented in dairy farms, goshalas, poultry farms, and clusters of rural households. Additionally, centralized waste collection and digestion systems can serve multiple villages, increasing energy access and reducing environmental pollution.

The application of enriched biogas can be extended to power generation using 100% biogas engines, further promoting rural electrification and entrepreneurship.

Solar Energy: Tapping the Power of the Sun

Solar energy stands out as one of the most promising renewable energy sources for dairy farming, thanks to its wide availability and cost-efficiency. solar technologies can be applied in numerous ways to make dairy operations more efficient and sustainable.

Dairy Cold Chain Development

WWF-India, in partnership with HSBC, initiated the solarization of dairy cold chains in Rajasthan and Uttar Pradesh. In Velangari village, there are 38 solar- powered milk chillers, collectively boasting a total capacity of 175 kW were installed, capable of processing 26,000 liters of milk daily. This initiative significantly reduced reliance on diesel generators and cut down operational costs. The target is to achieve 1,000 kW solar-powered dairy capacity, ensuring uninterrupted power supply and reducing the carbon footprint of milk chilling and storage.

Solar-powered Milking Machines

SELCO India introduced solar-powered milking machines in Karnataka and several other states. These machines, costing approximately ₹70,000, allow a single operator to milk 20–30 cows in just an hour. These solar-powered milk chillers have transformed the

milking process by minimizing manual labor, enhancing hygiene, and boosting efficiency. Additionally, over 330 solar milking machines have been distributed across states like Tamil Nadu, Andhra Pradesh, and Bihar, empowering farmers and increasing overall productivity.

Government Schemes and National Initiatives

The Indian government has implemented several programs to promote renewable energy adoption in dairy farming. These initiatives are spearheaded by agencies such as the National Dairy Development Board (NDDB) and the Ministry of New and Renewable Energy (MNRE).

Key Programs and Outcomes:

Mujkuva SPICE Project: India's first grid-connected farmers' solar cooperative.

It supplies clean energy to bulk milk chilling systems and has saved over 320 tonnes of carbon emissions.

Climate-smart Manure Value Chain: Developed by NDDB to convert waste into renewable energy and compost.

Solarization of Bulk Milk Chilling Units: Enhances energy efficiency and reduces diesel consumption.

Concentrated Solar Thermal Systems in Processing Plants: Applied for heating and pasteurization to lower thermal energy demand.

In the last two years alone, farmer members of the solar cooperative earned over ₹11 lakh, highlighting the economic feasibility and success of such projects.

Conclusion

The adoption of renewable energy in dairy farming is not just a technological shift—it is a transformative movement toward sustainability, economic efficiency, and rural empowerment. Through the integration of geothermal, biogas, solar, and wind energy, dairy farms can become self-reliant, environmentally friendly, and cost-efficient. Case studies from across India have shown that these technologies improve animal welfare, enhance milk quality, and generate additional income for farmers. They also contribute to national goals of reducing carbon emissions and increasing renewable energy capacity. As we move forward, greater awareness, policy support, and financial incentives are crucial to accelerating this green revolution. By embracing renewable energy, India's dairy sector can lead the way toward a cleaner, more resilient, and prosperous agricultural future.

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