

## Biomass Energy for National Energy Security, Sustainability and Rural Revitalization

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Biomass energy refers to various forms of energy derived from plants and microorganisms, including agricultural residues, forestry wastes, energy crops, and organic components of municipal and industrial wastes. It is a promising renewable energy source and an important part of the global sustainable energy system. As a renewable, carbon-neutral energy resource, it plays a critical role in replacing fossil fuels, reducing greenhouse gas emissions, and building a sustainable low-carbon energy system. It also plays an important role in ensuring national energy security, social sustainable development, and rural revitalization. It is an effective way of biomass valorization and an important component of the low-carbon economy. Great progress in biomass energy development has been made in recent years. However, large-scale biomass energy development is still facing great challenges. This editorial will give a brief discussion on biomass energy in relation to national energy security, sustainability, and rural revitalization. In addition, the challenges of large-scale biomass energy development will also be addressed.

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### Biomass Energy for National Energy Security

Against the backdrop of today's ongoing global energy transition and intensifying geopolitical conflicts that have disrupted traditional fossil energy supply chains, biomass energy has gradually emerged as a pivotal contributor to bolstering national energy security. Unlike intermittent renewable energy sources such as wind and solar power that rely heavily on weather conditions, biomass energy can provide stable, dispatchable baseload power, thereby effectively filling the gap left by fluctuating renewable output and reducing a country's reliance on imported fossil fuels. Its wide distribution across most regions also means that countries can develop and utilize local biomass resources, including agricultural residues, forestry waste, and organic municipal solid waste. This approach can avoid the price volatility and supply risks that come with cross-border energy transportation. By integrating biomass energy into existing energy systems, countries can diversify their energy mix, strengthen their independent energy supply capacity, and build a more resilient, secure energy infrastructure that can adapt to changing global energy landscapes.

### Biomass Energy for Sustainability

The global push toward carbon neutrality and circular economy has positioned this renewable resource as a key pillar of green transition. Unlike fossil fuels that release carbon

sequestered over millions of years, the carbon emitted during biomass combustion is offset by the carbon absorbed by the biomass feedstock during its growth, resulting in near net-zero carbon emissions. This carbon-neutral characteristic makes it an ideal complementary energy source for intermittent renewables such as wind and solar, providing stable, dispatchable power to balance fluctuations in grid supply and demand. Additionally, biomass energy drives circular development by turning agricultural residues, forestry waste, and organic municipal solid waste into usable energy, turning what would otherwise be a disposal burden into a valuable resource. This not only reduces methane emissions from landfills and open burning of waste but also cuts down on soil and water pollution, creating additional environmental and economic benefits for local communities.

### **Biomass Energy for Rural Revitalization**

As a resource that is mostly derived from agricultural and forestry production, biomass energy offers unique opportunities to inject new vitality into lagging rural economies. Developing local biomass energy projects creates a steady source of additional income for farmers and foresters, who can sell surplus crop residues, wood processing scraps and other feedstocks that would otherwise go unused, rather than leaving these materials to rot or burn in open fields. The construction and operation of biomass power plants, biogas projects and pellet production facilities also create large numbers of local non-farming jobs, helping to retain working-age populations in rural areas that have long faced labor outflows. Furthermore, the popularization of household biogas and biomass briquette heating improves access to clean energy for rural residents that are off the main gas grid, replacing traditional dirty solid fuels such as raw coal and firewood to improve both indoor air quality and living standards. When integrated with rural infrastructure upgrading, biomass energy development can drive the overall growth of rural industries, improve public services, and support the long-term revitalization of rural regions.

### **Challenges Facing Large-Scale Biomass Energy Development**

While biomass energy brings multiple benefits across energy, environmental and social dimensions, its widespread deployment still faces several notable constraints. The collection, transportation and storage of dispersed biomass feedstock require complex logistics systems, which often push up overall production costs compared to traditional fossil energy and some utility-scale renewable energy projects. There are also concerns over sustainable feedstock supply: large-scale demand for biomass may lead to over-harvesting of forest resources or competition with food production for land, if not properly planned and regulated. Additionally, the current technological maturity of some biomass conversion routes remains limited, with relatively low conversion efficiency and non-negligible emissions of minor pollutants that require further technological upgrading and strict emission control to address. To unlock the full potential of biomass energy, governments and industry need to work together to improve supply chain management, strengthen sustainable feedstock standards, increase research and development investment, and put in place targeted policy incentives to support healthy, orderly development of the sector.

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