

IMPACT SHEET: Biomass Gasification Technology – Sustainable Energy Solution for Agri-Food Processing and Waste Management in Rural Areas of Vietnam (BEST)

Turning Waste into Energy



Biomass Gasification Technology – a Sustainable Energy Solution for Agri-Food Processing and Waste Management



PROJECT BACKGROUND

Vietnam's rural agri-food processing sector is largely driven by micro, small and medium enterprises (MSMEs), which play a critical role in value addition, employment and rural livelihoods. However, most MSMEs continue to rely on coal, firewood and other inefficient combustion methods for processing, resulting in environmental pollution, adverse health impacts, higher production costs and inconsistent product quality. While substantial volumes of agricultural residues from agriculture and forestry production remain underutilised or are openly burned, contributing to greenhouse gas emissions and local air pollution. This situation highlights a missed opportunity to convert abundant biomass resources into cleaner and more affordable energy solutions. In response to these challenges, the BEST project was designed to address the dual challenge of unsustainable energy use in agri-food processing and poor agricultural biomass waste management, while supporting Vietnam's climate mitigation and green growth objectives.

CHALLENGE

Rural agri-food MSMEs in Vietnam remain structurally dependent on polluting and inefficient energy sources, while access to clean and affordable energy solutions suitable for small-scale enterprises is still limited. Significant quantities of agricultural biomass residues remain untapped, limiting their potential contribution to renewable energy production. These challenges are further compounded by limited awareness and technical capacity among MSMEs to identify, adopt and operate sustainable energy solutions, renewable energy technologies and green processing initiatives, as well as the absence of a coordinated market ecosystem linking technology providers, biomass fuel suppliers and end-users, which continues to constrain wider adoption and sustainable scale-up.

PROJECT OBJECTIVES

The BEST project aims to promote sustainable agri-food processing and contribute to enhancing waste management in Vietnam by facilitating the adoption of volumetric and continuous biomass gasification (VCBG) as renewable energy among agriculture micro and small enterprises (MSEs).

The specific objectives include:

- Agri-MSEs in the project provinces achieve improved product quality and efficient energy consumption and contribute to managing rural waste through application of VCBG.
- Increased availability of mechanical and biomass supply services and access to finance for agri-MSEs to deploy VCBG consistently.
- Buy-in and support from relevant government agencies for further adoption and replication of VCBG in agri-food processing and other industries.

TARGET GROUPS

- 2,000 agri-MSEs adopt VCBG
- 100 local mechanical enterprises are trained to produce VCBG equipment
- 400 people participating in the supply services of biomass as fuel for VCBG equipment
- 50 staff of financial institutions have improved knowledge and understanding of VCBG technology
- 50 government officials are reached through events and direct lobbying activities

PROJECT ACTIVITIES

Demonstration and economic validation of VCBG technology

The project established and operated 20 biomass gasification demonstration sites in four provinces, focusing on agri-food processing value chains. These sites served as practical learning platforms to showcase the technical performance, operational feasibility and environmental benefits of VCBG systems. In parallel, comprehensive cost-benefit analyses, including the potential use of biochar, were conducted to assess economic viability and support evidence-based decision-making for wider adoption.

Capacity building and technical support for adopting agri-food MSEs

The project strengthened the technical capacity of agri-food MSEs through Training of Trainers (TOT) programmes on VCBG promotion, complemented by tailored on-site technical assistance. This combined approach enabled enterprises to better understand, install, operate and maintain biomass gasification systems, reducing technical risks and increasing user confidence in clean energy adoption.

Awareness raising and outreach to agri-food MSEs

Targeted outreach and promotional activities were implemented to introduce VCBG technology to approximately 3,500 agri-food MSEs engaged in agri-food processing activities. These activities aimed to raise awareness of sustainable energy solutions and encourage informed consideration of biomass gasification as a viable alternative to conventional fuels.

Strengthening local mechanical service and manufacturing capacity

The project built the capacity of local mechanical enterprises to produce, maintain and promote VCBG equipment. Core mechanical technicians were trained through TOT programmes, followed by structured training and hands-on technical assistance for 100 key and capable local mechanical enterprises. Refresher trainings and coordination mechanisms were further implemented to support quality service provision and ensure the availability of local technical support for adopting agri-food MSEs.

Development and coordination of biomass supply services

To ensure reliable fuel supply for VCBG systems, the project supported the development of biomass supply service plans and strengthened the capacity of biomass coordination teams. Biomass suppliers and key ecosystem stakeholders were recruited and trained, while coordination mechanisms and dialogue platforms were facilitated to link biomass suppliers, agri-MSEs and mechanical enterprises within an emerging VCBG value chain.

Facilitating access to finance for VCBG investments

The project engaged financial institutions to improve understanding and credit assessment of VCBG-related investments through targeted technical assistance. In parallel, agri-MSEs and mechanical service providers received training on credit proposal development. Multi-stakeholder meetings and forums were organised to connect enterprises with financial institutions, support schemes and social investors, helping to reduce financial barriers to technology adoption.

Knowledge generation, policy engagement and advocacy

The project systematically documented good practices, success stories and lessons learned from VCBG deployment. Based on these insights, provincial policy recommendations were developed and discussed with local authorities to support scaling-up in other industries. In addition, national policies related to sustainable production, renewable energy, agricultural waste management and carbon emission reduction were reviewed to inform advocacy strategies, complemented by policy dialogues and outreach to business associations and key stakeholders.

LESSONS LEARNED

The implementation of BEST revealed that several initial assumptions regarding the readiness and scalability of biomass gasification technology were more complex in practice. The design and material suitability of VCBG equipment for agri-food processing at scale, the availability and consistency of suitable biomass, and the ease of technology adoption by MSMEs required more extensive field testing, redesign and adaptation than initially anticipated. These technical adjustments had cascading effects on project timelines and related interventions. Beyond technical performance, limited user confidence and willingness to adopt unfamiliar technology emerged as a critical barrier, highlighting the need for earlier and stronger integration of end-user engagement alongside technical validation in technology-driven projects.

In parallel, partnership and governance challenges significantly affected project implementation. While the collaboration between Oxfam and the technical partner initially combined complementary strengths, misalignment in governance, decision-making and adherence to partnership principles created serious risks to project integrity. Breaches of agreed protocols undermined trust and ultimately led to early project closure even though it was already approved for implementation extension. At the local level, limited ownership and capacity

among provincial partners, combined with low familiarity with adaptive and technically complex project models, constrained effective co-implementation and slowed early progress. These experiences underscore the importance of robust governance arrangements, transparent partnership structures, diversified market development and early capacity assessment of local actors in ensuring effective delivery and sustainable outcomes.

The BEST project highlights that technology-driven interventions in rural industrial settings require an integrated approach that balances technical innovation with user-centred design, adaptive management and strong governance from the outset. Rigorous field testing should be combined early with stakeholder engagement to build user confidence and ensure that technologies respond effectively to operational realities. Clear partnership governance, transparent decision-making mechanisms and regular review of partner capacity are essential to manage complexity and maintain alignment over time. In addition, sustainable scaling of clean energy technologies depends not only on knowledge transfer but also on the development of competitive local service and manufacturing markets, supported by access to finance and policy frameworks that enable long-term adoption and replication.

PROJECT ACHIEVEMENT

The BEST project delivered measurable environmental and socio-economic impacts through the adoption of biomass gasification technology in rural agri-food processing. In parallel, it established a functioning multi-actor ecosystem that enables continued technology uptake and provides a strong foundation for sustainable scaling beyond the project period.

- 3,800+ agri-food MSMEs were reached and trained on VCBG technology.
- 500 agri-food processing MSMEs adopted biomass gasification in practice.
- 77,600 tonnes of CO₂ emissions were reduced.
- 34,740 tonnes of biomass residues were effectively reused as renewable energy.
- 145 local mechanical enterprises and 14 biomass service providers were developed and strengthened, with 67% of adopting MSMEs expressing satisfaction with mechanical and biomass supply services.
- A functional VCBG ecosystem linking technology users, mechanical service providers and biomass suppliers was established and is operational at regional scale, providing a strong foundation for long-term sustainability and wider adoption.



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Transforming decades-old agri-food processing practices and overcoming strong resistance to new technology was a major challenge. Yet through continuous equipment refinement, hands-on on-site support and repeated real-world demonstrations, more than 500 enterprises ultimately shifted to VCBG technology. This change was made sustainable by the emergence of a local VCBG ecosystem, ensuring continued access and lasting environmental, economic and climate benefits recognised by enterprises, communities and local authorities.



Long-term project sustainability

The sustainability of the project's impacts varies across processing sectors, with strong prospects in small-scale green tea processing and more limited uptake in larger-scale and other agri-food subsectors. Despite the early-stage maturity of VCBG technology, the project established a solid foundation for scaling adoption by building a functional VCBG ecosystem that connects equipment producers, biomass suppliers, technical service providers and end-users, enabling continued learning, service provision and market-driven uptake. Through technology transfer, local actors are now able to further adapt equipment and biomass fuels to local operating conditions, while demonstrated benefits—including reduced operating costs, improved working environments, enhanced product quality and high user satisfaction—support sustained demand.

The project also strengthened the sustainability of VCBG commercialization by completing key legal and technical prerequisites, including cost-benefit calculations, durability assessment, price appraisal and basic standard registration, making the equipment eligible for public sale. However, long-term market development will require diversification of equipment producers and additional investment in local manufacturing capacity to avoid dependency on a single supplier. Overall, the project provides a credible pathway toward sustained and scalable adoption, provided that competitive market development and supportive policies continue beyond the project period.

Project contributions to Climate Change Mitigation and SDGs

The BEST project contributed directly to climate change mitigation by reducing greenhouse gas emissions through the substitution of fossil fuels with biomass gasification in agri-food processing. By enabling the reuse of agricultural residues as a renewable energy source, the project reduced reliance on coal and firewood, avoided open burning of biomass, and improved energy efficiency at enterprise level. The estimated reduction of 77,600 tonnes of CO₂ emissions demonstrates the project's tangible contribution to Vietnam's climate mitigation efforts, while also delivering co-benefits in improved air quality and safer working environments in rural areas.

The project also made a strong contribution to [SDG 12](#) (Responsible Consumption and Production) by promoting circular use of agricultural by-products and embedding cleaner production practices in agri-food MSMEs. Through the effective reuse of 34,740 tonnes of agricultural biomass, BEST advanced waste reduction, resource efficiency and sustainable production patterns. By establishing a functioning ecosystem that links technology users, mechanical service providers and biomass suppliers, the project supports longer-term behavioural change and market-based incentives for sustainable production beyond the project lifecycle.

Anchored in [SDG 12](#) (Responsible Consumption and Production) and [SDG 13](#) (Climate Action), the BEST project demonstrates strong interlinkages across the SDG framework by addressing energy use, waste management, livelihoods and local market development in an integrated manner. The deployment of biomass gasification enables circular use of agricultural residues ([SDG 12](#)), reduces greenhouse gas emissions ([SDG 13](#)), and expands access to cleaner and more affordable energy for rural MSMEs ([SDG 7](#)). These outcomes reinforce productivity improvements and safer working conditions in agri-food processing, supporting inclusive economic growth and decent employment ([SDG 8](#)), while fostering local innovation and service infrastructure for clean energy solutions ([SDG 9](#)).

Beyond its core focus, the project contributes indirectly to broader sustainable development objectives through ecosystem building and institutional engagement. By strengthening collaboration among enterprises, service providers and local authorities, the project supports more resilient rural communities and improved environmental management ([SDG 11](#)). Capacity building, knowledge transfer and stakeholder engagement enhance institutional effectiveness and partnerships for sustainable development ([SDG 16](#) and [SDG 17](#)). While not all SDGs are directly targeted, the project's integrated approach to clean energy, waste valorisation and market development creates enabling conditions for progress across multiple goals at local and regional levels.

Impacts at a Glance

Economic Impact	<ul style="list-style-type: none"> • 7 local mechanical enterprises have already expanded business activities to VCBG transition, while 138 have opportunities due to improved knowledge. • 14 local biomass supply enterprises have already participated in the biomass business. • A local company was established to handle commercialization of VCBG equipment and biomass fuel. • Hundreds of local technicians obtained technical knowledge and provided technical assistance on implementing VCBG. • More and more agri-food MSEs have been switching to VCBG from conventional processing, particularly in the tea sector due to economic, environmental and social benefits.
Environmental Impact	<ul style="list-style-type: none"> • 69,480 tonnes of firewood saved • 34,740 tonnes of unused biomass was resourced into fuel for energy
Social Impact	<ul style="list-style-type: none"> • Smoke from agri-food processing was significantly reduced leading to improved living environment and air quality for the community as well as the working condition in the processing facilities • Agriculture and forestry waste was collected and repurposed into fuel, reducing the risk of water supply and environmental pollutions • The project demonstrated VCBG technology on-site allowing large number of participants to observe and practice, so that women were encouraged to participate not like in-class trainings
Climate Benefits	<ul style="list-style-type: none"> • 77,600 tonnes CO₂e emission was reduced • Adoption of VCBG technology could reduce half of the fuel needed for drying the same volume of agri-food. Besides, VCBG technology turns carbon dioxide into syngas for heat generation and sequester a small amount in the biochar, so that it helps reduced GHG emissions.
Green Finance	<ul style="list-style-type: none"> • The project engaged 13 representatives from financial institutions in a demonstration and introduction of VCBG technology, helping them better understand the technology and, in turn, assess related loan applications more confidently and effectively.
Target Group Engagement	<ul style="list-style-type: none"> • Engaged 3,981 enterprises, including those in agri-food processing, mechanical service and biomass supply • 20 VCBG demonstrations for various types of agri-food processing • Hundreds of capacity building events were organized including TOT training, technical trainings for mechanics and biomass suppliers, on-site support and coaching, training on business management, gender mainstreaming.
Policy Development	<ul style="list-style-type: none"> • Raising awareness on green and renewable biomass energy among policy makers through showcasing VCBG technology in national and international events, like Mekong Start-Up Forum, the Global Conference of the Sustainable Food Systems Programme, Vietnam Energy Partnership.





FUNDING

EUR 3,041,814
(EU Contribution: 80%)



DURATION

Oct 2020 - Nov 2025



PARTNERS



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Study and Consultancy (CCS)



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This impact sheet is developed together with SWITCH-Asia Policy Support Component



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