Policy Brief

Sustainable vegetable cultivation using agricultural waste-derived biochar

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About the Hub

The Queensland Decarbonisation Hub brings together knowledge, people and innovation to co-create solutions to accelerate Queensland's clean growth future. We connect Queensland universities, industry, communities, First Nations people and government to build and share the knowledge needed to reduce emissions. The Hub's vision is for Queensland to become a leading decarbonised economy in which communities, industry and the environment thrive.

About this policy brief

In 2024, the Queensland Decarbonisation Hub initiated a funded research stream, inviting proposals for research that could contribute to understanding and supporting Queensland's decarbonisation transition. The Hub's Advisory Committee, which brings together representatives from industry and other sectors, helped inform the selection process by identifying areas where research could add value to emerging policy and practice. Eight projects were selected across a diverse range of topics, including the research featured in this brief.

Each project has produced a detailed technical report, which is undergoing review prior to publication. Alongside these reports, the Hub has worked with the research teams to consider a different question: what does the research mean for policy and practice?

This question was explored through a series of workshops and the Hub's Research Showcase, where researchers presented their findings to an audience drawn from government, industry, research and the wider community. These policy briefs build on that process. They are intended as short, accessible companions to the technical reports, highlighting the findings that matter most beyond the research itself and the questions and opportunities they raise for Queensland and Australia more broadly.

About this research

This project examines an important question for the energy transition: how can decarbonisation create new economic opportunities rather than simply reduce emissions? By converting agricultural residues into biochar, bio-oil and syngas, the research shows how agricultural waste can become a productive resource that contributes to both emissions reduction and agricultural productivity. In doing so, it highlights the potential for new value-added industries based on Queensland's existing agricultural strengths.

One of the distinguishing features of this research is that it combines engineering, agricultural science and environmental assessment with techno-economic analysis. This means the project considers not only whether the technology works, but also whether it has the potential to be deployed commercially under Queensland conditions. That broader perspective is important. Technologies will only contribute to the energy transition if they can be adopted at scale and provide viable opportunities for industry and regional communities.

While further demonstration will be required before commercial deployment, the research provides a strong foundation for future investment in Queensland's circular bioeconomy. It illustrates how innovation can generate multiple benefits simultaneously, creating new regional industries while supporting agricultural productivity, waste reduction and long-term carbon sequestration.

Dr Liz Young

Research Director, Queensland Decarbonisation Hub

From the Showcase Session Facilitator

What interested me about this research is that it treats agricultural residues as a resource rather than a problem in the energy transition, producing biochar using a microwave-assisted process to benefit stakeholders across the lifecycle. If it can improve soil health, store carbon and create new value for farmers, it has the potential to deliver practical environmental and economic benefits. The next step is demonstrating that it can work at scale and with other residues. Also, as an energy user, a biochar production system such as this could be a useful energy load in remote areas that could operate during peak solar generation times or between other energy intensive processes.

Andrew Chamberlin

Project Manager, Energy, Queensland Farmers' Federation

Queensland Decarbonisation Hub

1. Why this research matters

Queensland generates substantial quantities of agricultural residues each year from crop production and processing industries. Much of this biomass is underutilised, disposed as waste or left to decompose, resulting in lost economic value and avoidable greenhouse gas (GHG) emissions. In the meantime, Queensland agriculture faces increasing pressure to improve soil health, maintain productivity under changing climatic conditions, and contribute to state and national decarbonisation targets.

Biochar has emerged as a promising solution because it can convert agricultural waste into a stable carbon-rich product that improves soil performance while storing carbon for extended periods. However, there remains uncertainty regarding the environmental benefits, economic viability, and practical application of biochar produced from Queensland agricultural residues.

This project investigated whether agriculture waste (e.g., hemp) could be converted into high-value biochar using microwave-assisted pyrolysis (MAP), a process that uses microwaves to heat organic material in the absence of oxygen, producing biochar, bio-oil and syngas The project also evaluated whether the resulting biochar could improve crop growth while contributing to carbon sequestration and emissions reduction.

2. Key findings

The project demonstrated that MAP could convert hemp waste into high-quality biochar along with other byproducts such as bio-oil and syngas, creating a pathway for transforming agricultural waste into valuable products rather than just being disposed of in a landfill.

Biochar produced through the MAP process exhibited substantially improved physical properties compared with raw biomass. Surface area increased from approximately 1 m^2/g in raw hemp residues to almost 150 m^2/g in the highest-performing biochar. This created a much more porous material that can hold more moisture and nutrients, improving the biochar's suitability for soil applications.

Pot-based and field studies showed that biochar application improved plant growth, biomass production and overall crop performance. Several biochar treatments outperformed both untreated soils and commercially available biochar products.

The biochar produced retained approximately 62–68% of the original biomass carbon, demonstrating significant long-term carbon sequestration potential. Across all operating conditions, the MAP process stored substantially more carbon in the biochar than it released as GHG emissions during production, indicating strong potential for net emissions reduction.

Techno-economic analysis indicated that commercial deployment could be economically viable, particularly when biochar, bio-oil, and recovered energy are utilised within an integrated circular economy framework.

3. Why the findings matter in practice

The findings demonstrate that agricultural waste can become a valuable resource for both emissions reduction and agricultural productivity. Biochar production provides a practical pathway for supporting Queensland's transition to a circular bioeconomy by reducing waste, creating new revenue streams for agricultural industries, and improving soil performance.

The ability to store a substantial proportion of biomass carbon in stable biochar offers an opportunity to support carbon sequestration and potentially contribute to future carbon accounting and carbon-credit frameworks. For regional communities, biochar production could create additional economic opportunities while strengthening agricultural resilience and sustainability.

The research also demonstrates that decarbonisation initiatives can deliver multiple co-benefits simultaneously, including waste reduction, improved soil health, enhanced crop productivity, renewable energy generation, and long-term carbon storage.

4. Who should pay attention

Government and policy agencies could leverage the study to support circular economy initiatives, agricultural decarbonisation, carbon sequestration strategies, and regional economic development.

Agricultural producers and industry groups could use the findings to identify new pathways for managing agricultural residues while improving soil productivity and farm sustainability.

Biochar producers and technology developers could encourage investment in scalable biochar production systems and regional processing facilities.

Carbon market developers and environmental agencies could take advantage of the findings to evaluate opportunities for recognising biochar-based carbon sequestration within emerging carbon accounting frameworks.

Regional development organisations and local governments could explore waste-to-value opportunities that create economic and environmental benefits for regional Queensland.

Researchers and innovation providers could further optimise biochar production systems and evaluate performance across a broader range of crops, soils, and climatic conditions.

5. What could happen next

The findings support progression toward larger-scale demonstration projects involving agricultural producers, biochar manufacturers, and regional stakeholders. Future work should focus on validating long-term field performance, quantifying carbon sequestration outcomes under Queensland conditions, and assessing commercial deployment pathways for regional industries.

Further development could include integration of biochar production into existing agricultural processing operations, evaluation of additional feedstocks such as sugarcane bagasse and horticultural residues, and investigation of carbon-credit opportunities associated with biochar deployment.

Demonstration-scale facilities would provide valuable evidence to support policy development, investment decisions, and wider adoption across Queensland's agricultural sector.

6. Points to note

The findings are based on laboratory, glasshouse and controlled field studies using hemp-processing residues as the primary feedstock. While results demonstrate strong potential, broader commercial implementation will require further validation across different feedstocks, soil types, climatic conditions, and production scales.

Economic outcomes remain sensitive to biochar market value, electricity costs, feedstock logistics, and future policy settings relating to carbon sequestration and emissions reduction.

7. Contact

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