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CIRCULAR ECONOMY BUSINESS CASE STUDIES IN SOUTHEAST ASIA

Khmer Green Charcoal (KGC)

Phnom Penh, Cambodia
Char briquettes
kgc-cambodia.com
Analysis period: 2012-2023

Char Briquettes from Coconut Shells

Business Spotlight

Khmer Green Charcoal Co., Ltd. (KGC) is pioneering a circular solution in Cambodia's cooking fuel sector by transforming waste coconut shells into high-quality char briquettes, effectively combating the deforestation caused by traditional wood charcoal production.

In addition to introducing resource circularity, KGC made significant innovations in the carbonisation process by developing highly efficient TLUD (top-lit up draft) kilns and by insulating the ovens used for the high-temperature process. These in-house developed kilns provide superior control over the pyrolysis process, enhancing efficiency and reducing emissions. The result is a carbonisation process that is both clean and energy- and material-efficient.

KGC's advanced industrially engineered process has earned them accolades and ISO 9001:2015 certification for the quality management system for charcoal production. From 2012 to 2022, it is estimated that KGC prevented the deforestation of approximately 465 ha and reduced over 48,000 metric tonnes of CO_2 emissions. The briquettes are efficient because they burn longer and emit fewer air and greenhouse gas emissions (GHGs), and they achieve resource circularity by efficiently utilising the biomass energy.

Despite strong competition from low-cost, traditional charcoal products, KGC has built a diverse customer base by emphasising product quality and cost savings. The company is aiming for international market expansion along with a fivefold increase in production within the next 2–3 years. KGC also prioritises social sustainability by providing fair employment opportunities and education support for the employees.

This circular solution offers replication potential in other developing regions, aligning with global sustainable development goals. KGC's success showcases the power of circular-economy driven innovation in a competitive setting, and highlights the importance of strategic partnerships and local investments for achieving long-term financial sustainability.

Keywords

Deforestation, Char briquettes, Innovation

Innovation

Product/service design, Manufacturing, End-of-life management, Resource circularity, Resource efficiency

Analysis of Khmer Green Charcoal

Context and baseline

Khmer Green Charcoal Co., Ltd. (KGC) was created to offer a sustainable alternative to traditional, unsustainable wood charcoal, and using coconut shells to produce char briquettes, directly combatting deforestation. Cambodia has experienced an annual deforestation rate of 2.68% in the past decade, with charcoal production significantly contributing to this issue. Data from 2015[1] highlighted that 14,000 hectares of Cambodian forest were annually cleared solely for the purpose of charcoal production.

The technology behind the production of char briquettes from coconut shells was conceptualized by GERES, a French non-profit organisation that implemented an improved cookstove project and piloted various carbonisation techniques to create a 'sustainable' fuel to further enhance the efficiency of the stoves. Mr. Carlo Figa Talamanca, one of the consultants in the organisation, took over the initiative which started as an NGO project in 2010 and established Khmer Green Charcoal as a private company in 2012. This inclusive business successfully refined and commercialised the novel carbonization process, ensuring the successful sustainability of the project.

Innovation

Charcoal cooking briquettes, particularly from Khmer Green Charcoal (KGC), offer a superior alternative to traditional charcoal. They demonstrate higher energy density, better efficiency (as they burn longer), reduced smoke emissions, and eco-friendliness because their source is biomass waste instead of wood. While charcoal briquette production is not new, it is rarely sustainable, especially in developing countries where it competes with low-cost charcoal.

KGC produces mainly two types of char briquettes, both with an extruded hexagonal shape for easier storage and transportation: 'diamond' quality briquettes are produced 100% from coconut shell charcoal, and 'premium' quality is a mix of coconut shells and charred mixed biomass residues.

Two key innovations can be highlighted:

Resource circularity innovation: KGC substitutes wood with waste coconut shells, reducing deforestation pressure and the associated GHGs. Coconut shell is a type of biomass raw material that, when carbonised, produces a high fixed-carbon content (over 80%) and low ash content. Other biomass with similar properties are wood, corn cobs and palm oil kernels. Coconut shells, however, offer superior advantages in Cambodia in terms of availability, cost and logistics.

Resource efficiency innovation: KGC has introduced significant innovation in the carbonisation process with the development of the highly efficient TLUD (top-lit up draft) kilns. This proprietary kiln technology and design took inspiration from the development and application of TLUD in gasifier stoves (a result of open collaboration between several research institutes working globally on clean cookstoves). The KGC kilns provide superior control over the pyrolysis process, resulting in higher-quality charcoal (less smoke, longer burning), better biomass-to-charcoal conversion efficiency (more charcoal per unit of biomass used), and lower air emissions. Typically, coconut shells lose about 80% of the original mass in conversion to charcoal. TLUD technology makes it possible to capture and reuse methane and other volatile organic byproducts generated during pyrolysis as energy sources for the drying of the char briquettes in the final stages of the production process.

1 Yann François, Vannareth Huoy, and Romain Joya, *Charcoal, Forests and Livelihoods in the Northern Cardamoms, Cambodia* (Phnom Penh, Cambodia: Geres, February 2015).

The result is a clean and energy- and material-efficient carbonisation process.

Furthermore, KGC's unique pyrolysis and drying technology is capable of drying high-density briquettes within 24 hours, allowing the production of strong, uniform, high-quality char briquettes with minimum moisture content (< 8%). Production is further optimised with process monitoring and automation, reducing costs and increasing both productivity and quality, making it more competitive in the market. These innovations have earned them awards like the International Ashden Award for Sustainable Energy in 2014, and ISO 9001:2015 certification of quality management system for charcoal production.

This innovation not only improved product quality, but it also helped establish a formal value chain from coconut shell to quality assured charcoal in Cambodia, as opposed to traditional char-briquette production of variable quality and non-traceable wood supply by informal producers.

Circular Economy impact

KGC's innovative process for producing high-quality charcoal from coconut shells contributes significantly to the circular economy transition, in particular by making a circular use of coconut shells through pyrolysis (and also using the pyrolysis by-products as fuel source for the drying of briquettes), an illustration of resource circularity; and by making more efficient use of both the material and the energy contents of he coconut shells, showing resource efficiency. The increased circularity and efficiency of coconut shell use unlocks further environmental benefits, particularly in reducing GHGs, smoke, and air pollution, and by conserving both nature and biodiversity.

Resource Circularity: KGC's product is an example of resource circularity, because coconut shell waste is used as a biomass source for charcoal production. In the main pyrolysis process for producing charcoal, KGC captures the volatile organic by-products, including methane, and uses them as fuel to produce the necessary heat for the pyrolysis process and drying the final charcoal product. Moreover, waste production is reduced to a minimum in the factory because the coconut dust that results from carbonisation is collected and repurposed as organic fertiliser for tree nurseries.

Resource Efficiency: Both the production and the use of KGC charcoal demonstrate resource efficiency. Production is efficient because it achieves higher biomass conversion efficiency by producing more charcoal per unit of biomass carbon used, resulting in a higher fixed carbon content of the charcoal (83% for KGC diamond quality charcoal compared to 64% for regular charcoal). The KGC product thereby achieves higher energy efficiency, longer burning times (4–5 hour, which is 3–4 times longer than regular charcoal) and producing fewer air emissions (as the KGC briquettes contain only 13% volatile organic matter as opposed to 34% in regular charcoal).

Deforestation: The KGC char briquettes mitigate deforestation pressure. Producing the equivalent of KGC charcoal production for the period from 2012 to 2022 from wood would - according to KGC's calculations - have required harvesting of 465 ha of Cambodian forests. Illegal logging for traditional charcoal production is already damaging ecosystems, leading to permanent biodiversity loss in Cambodia's lowlands and mountains. Using coconut shells as substitute for wood in producing charcoal via advanced technology is thus protecting biodiversity, minimising soil erosion, and taking action against climate change.

Reduction in methane emissions: KGC's unique carbonization technology, which recovers carbonisation gases (synthesis gas or syngas) results in a significant reduction of methane emissions. Charring kilns without a recovery system emit approximately 40 kg of CH_4 per metric tonne of charcoal produced, representing an equivalent of 3.2 metric tonnes of CO_2 per metric tonne of charcoal over a 20-year lifespan.

GHG emission reductions arise from preventing deforestation, capturing and using methane emissions during the process, and gaining efficiency in the production and use of charcoal. Using the specific methodology approved by the UN Framework Convention on Climate Change[2], the combined impact of all these innovations is a mitigation of 48,000 metric tonnes of CO_2 emission from deforestation for the charcoal produced during 2012–2022.

This comprehensive approach showcases KGC's commitment to circularity, sustainability, and environmental conservation within the charcoal industry.

Business and market impact

Since 2012, Khmer Green Charcoal (KGC) has shown steady growth by increasing production from 4 metric tonnes monthly in 2012 to 4 metric tonnes per day in 2023. Nevertheless, KGC's production represents a mere 1% of Cambodia's total charcoal market share. KGC's growth has been organic,

2 https://cdm.unfccc.int/methodologies/DB/S4V8CI7HHKADRWTLKZO6CRK3LHAGEQ

initially supported by a few grants and the support of Pour un Sourire d'Enfant, a French NGO that provided land for operations.

Despite a clear business potential and interest from global impact funds, securing substantial external investment is a challenge, due mainly to economic constraints, including the disruptive effects of COVID-19 pandemic. However, KGC has plans to construct a new plant and multiply current production capacity five-fold within 2–3 years, targeting a return on investment in less than 2 years. KGC would also like to expand to other regions in Cambodia, such as Siem Reap Province. For now, KGC estimates that it is currently using less than 10% of the available coconut shells in Phnom Penh, making this raw material suitable for further increase in production capacity in Cambodia, even if KGC keeps experimenting with new available biomass waste.

What is noticeable is KGC's ability to carve out a 'captive market' despite higher prices – 2-3 times that of wood charcoal – for their top quality 'diamond' briquettes. Their diverse customer base spans from luxury hotels to street vendors, all attracted by the durability and long-term cost efficiency of the briquettes.

About 85% of KGC's char briquettes are sold in the capital Phnom Penh, with the remaining 15% sold in nearby provinces.

The global charcoal market extends far beyond developing nations, with Europe consuming 1 million metric tonnes annually, 75% of which is imported, often illegally. A 2020 WWF study revealed a growing demand for certified sustainable charcoal, hinting at some potential opportunities for KGC.

Until 2019, roughly 10% of KGC production was sold in niche international markets in Japan and Germany. Steep rises in container shipping costs and COVID-19 disruptions, however, have temporarily halted KGC's exports; they are actively planning to resume exports in 2024.

Stakeholders

KGC collects and purchases coconut shells from processing facilities in and around Phnom Penh. The majority of KGC's suppliers are micro and small enterprises, found in the local markets, who produce coconut water or shredded coconut meat, or who run coconut oil and other coconut-based food-processing businesses.

With 42 workers, KGC offers socially equitable employment opportunities to underprivileged individuals in Phnom Penh's suburbs, many of whom were formerly waste pickers. Additionally, KGC collaborates with the French NGO Pour un Sourire d'Enfant to support the schooling and education of the employees' children. KGC are committed to their employees, providing benefits like health insurance, seniority, and a 13th-month salary.

The KGC workforce is characterised by extremely low turnover, and 70% of their management are women as well as 40% of the workers, thanks to their mechanised and automated production process.

Implementation

KGC's primary challenge is the competition with very low-cost local lump-wood charcoal, often sourced from illegal logging activities. In 2016, in view of KGC's support to the Government's deforestation reduction agenda, KGC effectively negotiated and secured a VAT exemption for its char briquettes. As the sole registered company in this sector, their success might potentially open doors for future 'green' enterprises to access similar tax benefits.

Despite their char briquettes being twice as expensive as traditional wood charcoal, KGC initially stimulated demand by extensively offering product samples to potential customers for trial periods. At present they have fostered a loyal customer base and established a highly efficient distribution and delivery system, aided by their convenient hexagonal-shaped product that simplifies transportation and storage.

With the global charcoal market valued at approximately USD 16 billion (with figures ranging from USD 6–20 billion) and an annual consumption of 54 million tonnes worldwide, KGC's business model holds substantial potential for replication in Southeast Asia, Sub-Saharan Africa and South America, regions where charcoal is still one of the primary cooking fuels. KGC's parent company, Otago, offers advisory services and technical support for implementing similar production systems in other countries, including the provision of production equipment. Recently, a production unit was established in Kiribati as an example of this potential for replication.

Takeaways

The char briquette innovation spearheaded by KGC epitomises how innovation can drive success within a constrained developing economy context, aligning with Cambodia's goals to reduce deforestation by 50% by 2030 and achieve net zero emissions from forestry by 2040.

KGC's pivotal success factors lie in the superior quality of its char briquettes and the efficiency of its production process. Despite commanding a price twice that of traditional charcoal, KGC's high-calibre briquettes maintain their status as 'bestsellers', even among street vendors.

Still, as KGC's founder Carlo Talamanca has noted, 'to have an impact, you need to be financially sustainable first'. In Cambodia's context, attracting international investment and scaling up low-margin manufacturing sectors poses challenges, and addressing them could involve reshaping the mindset of local business, fostering strategic partnerships, and cultivating local investment into circular solutions. It is hoped that such a strategic shift could unlock avenues for sustainable growth and innovation in Cambodia's business landscape.

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