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How Wood Pellets are Improving Health and Ecology in Rwanda

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This white paper shows how wood pellets and high efficiency gasifying pellet cookers will be beneficial to the people and ecology of Rwanda and many other countries in which people use smoky solid fuels for cooking.

Globally, 2.3 million premature deaths are attributed to household air pollution from dirty cook stoves using charcoal or stick wood emitting high levels of particulate matter, black carbon, and carbon monoxide¹.

The use of charcoal and stick wood for cooking is common for most households in Rwanda². Both of those solid fuels are contributing to poor health.

The cutting down of trees to make charcoal or for firewood use is causing significant deforestation.

Using wood pellets in simple but highly efficient cookers significantly lowers carbon monoxide emissions and smoke (particulates and black carbon) and reduces the amount of wood needed to produce cooking fuel by 70% to 80%. This would lower wood demand to a sustainable level and deforestation would not be needed.

Work is being done to improve household pollution and reduce deforestation.

FutureMetrics is honored and proud to be providing analysis and consulting services to [BioMassters](#) via the support of the [Clean Cooking Alliance](#) (an organization within the United Nations). The efficient and safe production of wood pellets from sustainable feedstock is essential to the success of the clean cooking strategic goals.

A New and Highly Beneficial Use for Wood Pellets

The wood pellet markets have traditionally been divided into two major sectors: heating pellets and industrial pellets³. Figure 1 below shows that the combined heating and industrial pellet demand in 2021 exceeded 42 million metric tonnes.

¹ "Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019", Abbatati, C. et al. *Lancet* 396, 1223-1249 (2020), <https://www.sciencedirect.com/science/article/pii/S0140673620307522>

² "Pellet-Fed Gasifier Stoves Approach Gas-Stove Like Performance during in-Home Use in Rwanda", Wyatt M. Champion and Andrew P. Grieshop. *Environmental Science & Technology* **2019** 53 (11), 6570-6579, <https://pubs.acs.org/doi/full/10.1021/acs.est.9b00009>

³ Industrial pellets are a high energy density solid fuel used to replace coal in power and in combined heat and power generation. Heating pellets are used in stoves and boilers to produce heat and hot water for homes and businesses.

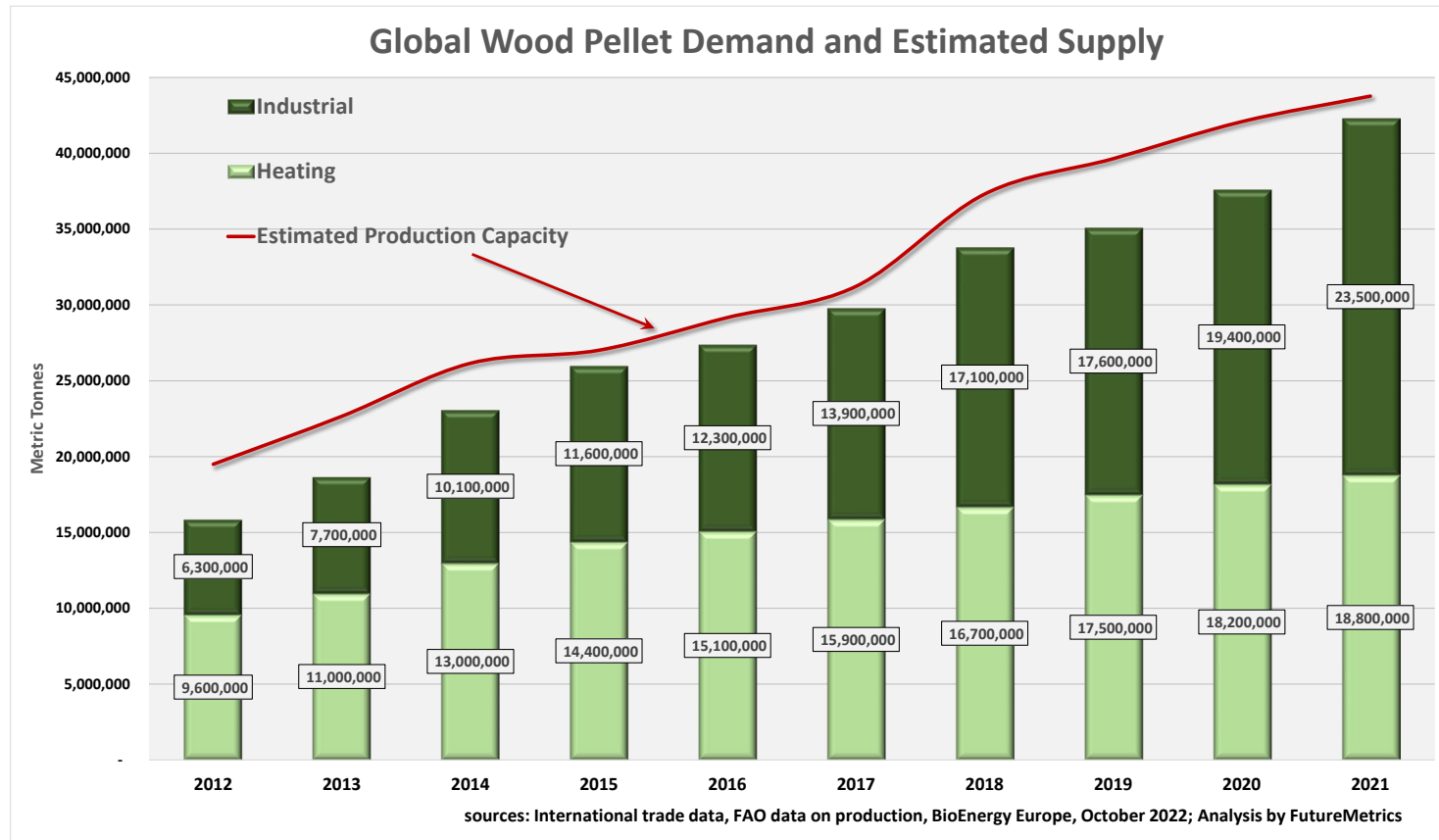


Figure 1 - Combined Heating and Industrial Pellet Supply and Demand

Cooking with pellets is not totally novel. In recent years, primarily in the US, a market for barbecue pellets has emerged. BBQ pellets are typically 100% hardwood and are used in purpose-built pellet BBQs. BBQ pellets are expensive and thus are limited to niche markets in rich countries.

Cooking with pellets has been confined to the BBQ pellet niche which relies on pellet expensive pellet BBQs that use mains electricity⁴ and costly specialty pellets.

But that is changing in a very positive way.

While pellet BBQs require mains electricity to regulate temperature, create draft, and operate the fuel feeding system, innovations in small autonomous pellet cookers have been impressive in recent years. Small pellet gasification stoves developed by [Mimi-Moto](#) that do not require mains power are fully compliant with [ISO/IWA Tier 4](#) emissions limits. They work cleanly and efficiently on regular low-cost heating pellets produced from local feedstocks.

⁴ https://en.wikipedia.org/wiki/Mains_electricity



Figure 2 - Mimi-Moto Pellet Cooker

Health Benefits are Significant

Most households in both rural and urban areas of Rwanda use charcoal or firewood. Charcoal is used mostly in urban areas and firewood is used mostly in rural areas. The emissions from the poor combustion of charcoal and stick wood are very dirty. Smoke and carbon monoxide (CO) are emitted at unhealthy levels. In 2019, household air pollution primarily from cooking was a top-ten contributor to the adjusted life years of the global population. The risks are higher for women, children and low-income countries⁵.

High efficiency gasifying pellet cookers eliminate most of these threats to health. Figure 3 below shows both particulate emissions⁶ and CO emissions from charcoal, firewood, and pellets.

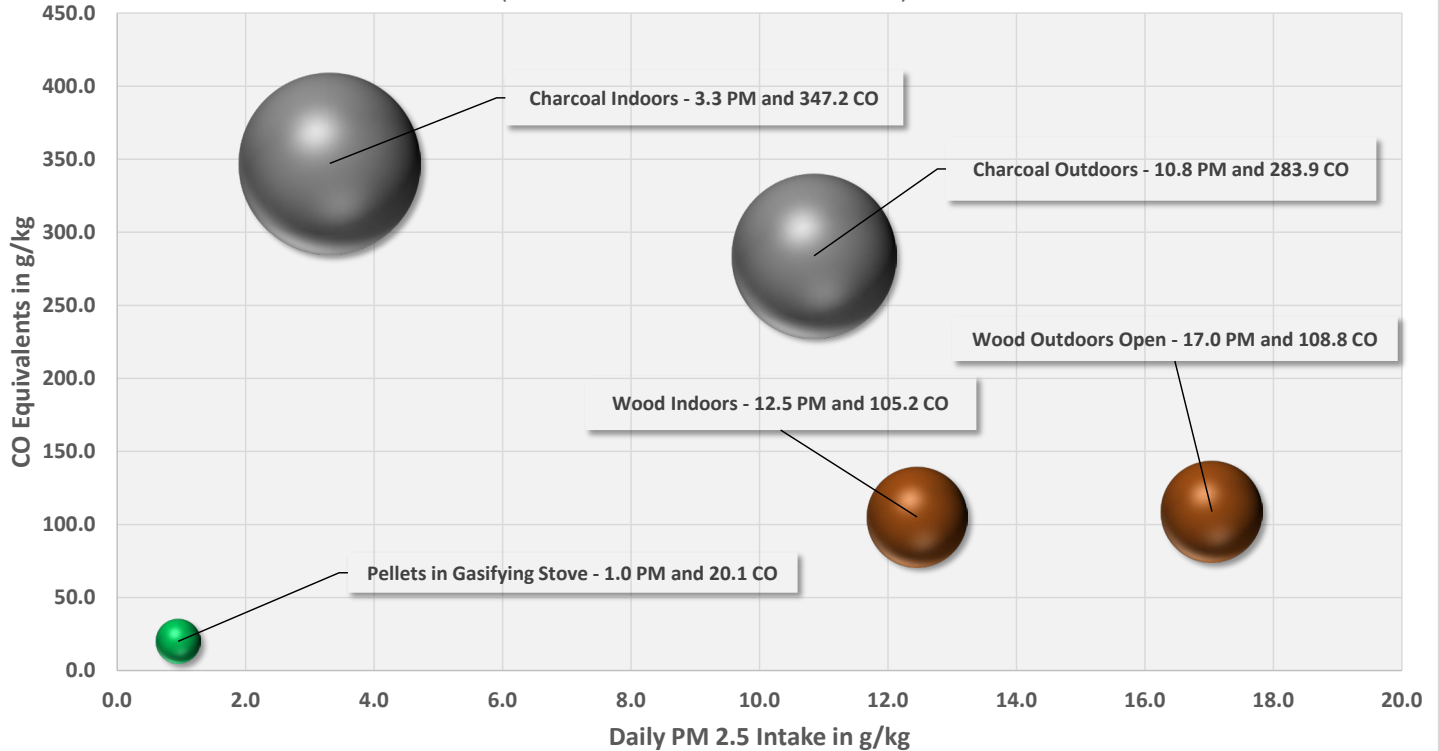
⁵ See footnote 1.

⁶ Particulates in the chart are PM 2.5. These are small particles that are 2.5 microns or smaller. See [HERE](#) for more detail on PM 2.5.



Particulate and Carbon Monoxide from Cooking in Rwanda

(bubble size relative to CO emissions)



Source: See footnote #2. Analysis and graphs by FutureMetrics

Figure 3 - Particulate and Carbon Monoxide from Cooking in Rwanda

Switching to pellets for cooking in a modern high efficiency pellet cooker will have significant positive health benefits.

But that is not the only benefit.

Ecological Benefits are Significant

In 2020, about 83% of Rwanda's energy consumption for cooking was with charcoal or firewood. This has caused significant deforestation. The problem is getting worse because population growth is intensifying deforestation and environmental degradation⁷.

Using pellets in high efficiency cook stoves lowers the demand for primary wood by 70% to 80%. Figure 4 below illustrates the dramatic reduction in the demand for wood if pellets are substituted for charcoal and stick wood.

⁷ Eustache Hakizimana, U. G. Wali, Diego Sandoval, Kayibanda Venant, "Environmental Impacts of Biomass Energy Sources in Rwanda," Energy and Environmental Engineering, Vol. 7, No. 3, pp. 62 - 71, 2020.

<https://pdfs.semanticscholar.org/7a20/17aa4e044f77c4fcd6b008e3d5201c8e8.pdf>

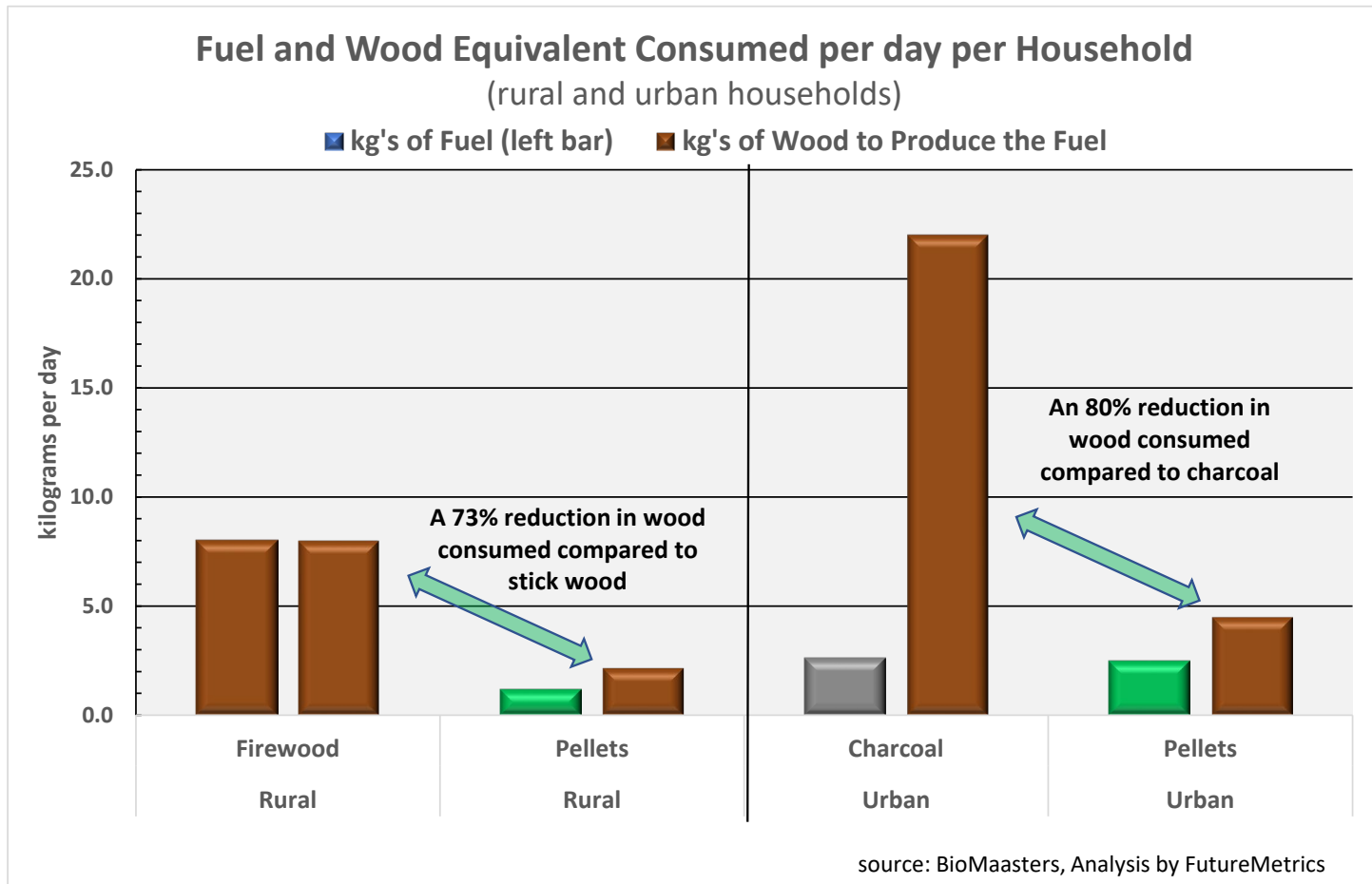


Figure 4 - Fuel and Wood Equivalent Consumed per day per Household

In general, rural households use firewood and urban households and restaurants use charcoal. Figure 4 has rural on the left side and urban on the right side. Urban households tend to have higher income, eat more, and thus use more cooking energy.

If wood pellets are used for cooking, the dramatic reduction in wood demand will change Rwanda's forest dynamics.

What about Cost?

The major barriers to conversion would seem to be the cost of the advanced biomass stoves and the cost of the pellet fuel. But as the analysis below shows, there are no cost barriers.

In Rwanda, BioMassters has implemented a "lease to own" model in which the stove is paid for over two years with no interest. Currently the Mimi-Moto retails on [Amazon](https://www.amazon.com) for US\$107. Assuming that wholesale cost delivered to Rwanda is US\$60, over 24 months that is a monthly cost of \$2.50 or a daily cost of just over 8 cents.



Data in a 2022 study⁸ by the University of California shows that based on cost per kilogram, pellets are cheaper than charcoal in Rwanda.

Table 1 - Affordability of Cooking Fuels in Rwanda

Affordability Index in Rwanda	
Fuel	9 = most affordable 0 = least affordable
Firewood	9
Pellets	8
Charcoal	7
Coal Briquettes	6
Kerosene	5
Ethanol from Wood/Sugar Cane	4
LPG	3
Electricity	2
Natural Gas	1
Biogas	0

Firewood is less costly per kg. But that does not recognize the fact that stick wood has a high moisture content (up to 55% if freshly cut). The water in the wood not only has no energy but also uses some of the wood's energy as it is evaporated from the wood. That lowers the useful energy per kilogram significantly. That combined with the fact that stick wood is often used in an open stone pit results in many more kilograms needed for cooking with wood versus charcoal and dry densified wood pellets.

Pellet fuel is clearly the lower cost fuel when the daily cost of fuel is calculated. Table 2 below shows this.

Table 2 - Net Cost of Cooking Fuels in Rwanda

Cost of Cooking Fuel in Rwanda					
		US\$/kg	kg's Used per Day	Daily Fuel Cost	Reduction in Fuel Cost
Rural	Firewood	\$0.17	8.00	\$1.36	
	Pellets	\$0.20	1.20	\$0.24	
			Difference ==>	\$1.12	82%
Urban	Charcoal	\$0.29	2.63	\$0.76	
	Pellets	\$0.20	2.50	\$0.51	
			Difference ==>	\$0.26	33%

Adding in the daily lease cost of \$0.08, pellets are still the most economical.

⁸ <https://rael.berkeley.edu/wp-content/uploads/2022/08/A-Proposed-%E2%80%9CAffordability-Index%E2%80%9D-for-common-cooking-fuels.pdf> Data on Rwanda is on page 12.



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Conclusion

Hysteresis generated by a long history of using stick wood and charcoal is a cultural barrier that will take time to overcome. To help to increase the rate of change, the BioMasters' pellet cooker lease includes customer service to help alleviate households' concerns over ease of use and reliability.

But it will also take time to build up pellet production and distribution infrastructure. Several companies are working on this challenge.

With critical support from the Clean Cooking Alliance, BioMasters has already reached the 1000 stove milestone and expects to rapidly increase the rate of transition. In parallel to eliminating dirty cooking with gasifying pellet cookers, new pellet production capacity is being built. The new BioMasters pellet factory that will be built under the guidance of FutureMetrics will produce enough pellets for 10,000 households. Other groups are doing similar work in not only Rwanda but also in other African nations.

The feedstock for the BioMasters new and future pellet factories will be sourced from the by-products of sawmilling companies and from the forest residuals from the harvest of sawlogs. Forest residuals are the tops and branches, and those part of logs that are rotted in the middle or are too crooked for lumber production.

This is quite the opposite of current practices for charcoal production and firewood gathering.

Better health and better ecology and lower cost fuel: a win-win-win for everyone!

