

Fuel from the Fields

Charcoal

B a c k g r o u n d

More than 2 billion people use wood, charcoal, dung or agricultural residues as the primary fuel for their cooking and heating needs, leading to significant health, economic and environmental consequences. Burning wood or agricultural residues produces smoke with a variety of irritant pollutants, some of which are known carcinogens. More than 1.5 million deaths a year are caused by acute respiratory infections from breathing smoke from indoor cooking fires. Women and children are generally exposed to the greatest levels of pollutants and it is children who suffer the greatest health risk – respiratory infections are the leading cause of death of young children worldwide.

Small-scale subsistence farmers who make less than US\$2 per day may use wood charcoal for cooking fuel. In areas where wood is scarce and farmers are not able to collect it themselves, the cost of cooking fuel is a significant drain on their limited resources. An estimated 50 billion hours are spent collecting firewood each year and families can spend over 25% of their income on fuel, leaving them with less income to cover other basic needs such as medicine, food and clean water. For comparison, even the poorest 20% of the U.S. population spends only 1% of their income on energy for their household.



In the year 2000, indoor air pollution from solid fuel use was responsible for more than **1.6 million annual deaths** and 2.7% of the global burden of disease.
-World Health Organization



Furthermore, many areas of the developing world face massive environmental problems due to deforestation as almost half the world's timber harvest is burned for fuel. For example, Haiti is 98% deforested as a result of demand for fuel. Due to necessity driven by severe economic and political instability, the remaining trees continue to be cut down. Deforestation results in devastating soil erosion – a major contributor to the hundreds of lives lost every year due to mudslides and flooding – and can also lead to longer term detrimental effects such as the degradation of aquatic life along the coasts of Haiti.



YouTube video of a charcoal burn and press demonstration with Amy Smith.

Several attempts have been made to introduce environmentally-friendly, cleaner cooking alternatives such as solar cookers, fuel-efficient stoves and charcoal briquettes made from paper. Solar cookers can be slower than traditional stoves, may work only during limited hours on sunny days, and are often unable to fry foods, which precludes them from being used to cook many traditional dishes. Fuel-efficient stoves have started to be disseminated in regions ranging from India to Sudan, but while they reduce the consumption of wood-based or fossil fuels, they may not necessarily eliminate it. An effort to produce briquettes from waste paper was introduced to reduce wood use, but initially these briquettes can be difficult to use and they still produce a significant amount of smoke. Furthermore, waste paper is not readily available in many rural areas. For alternatives to traditional cooking to be met with better success, they must prove to be affordable, effective and culturally acceptable.

In 2002, D-lab at MIT developed a radically different solution called “Fuel from the Fields” that addresses the problem of fuel scarcity with the economic needs of small-scale farmers in mind. The project offers farmers a way to turn their agricultural waste into charcoal, a cooking fuel alternative that is more affordable and healthier than wood-based fuels. While charcoal-making technologies have been around for thousands of years and other charcoal initiatives exist, they are often based on a centralized production and distribution model that can require a capital investment of tens of thousands of dollars. This charcoal can be made locally and inexpensively and has positive health, environmental and economic benefits: it burns cleanly, reducing exposure to the smoke that causes respiratory infections; it uses agricultural waste materials, and therefore does not contribute to deforestation; and it transforms a waste stream into a high-value, income-generating product – in Haiti, a bag of charcoal sells for US\$10. Charcoal from agricultural waste can also be paired with complementary technologies like fuel-efficient stoves to further reduce fuel consumption. By producing their own charcoal, farmers can not only save money that would have been spent on cooking fuel, but can sell excess charcoal in the market for an additional revenue stream.

To make the charcoal, agricultural waste materials appropriate to the season and the region are carbonized in a kiln made from a 55-gallon oil drum. The carbonized material is then crushed and formed into briquettes using a small press and a binder made from a source of starch such as cassava, a common root vegetable also known as yucca and manioc. The process takes a few hours and requires only simple devices which can be made from local materials and production methods for less than US\$25. A farmer can produce enough charcoal to pay for the equipment and start making a profit in less than a month. Microcredit institutions can also provide loans to help entrepreneurs that cannot afford the initial investment, or farmers can form charcoal-making cooperatives with a group ownership model. The decentralized approach of Fuel from the Fields helps minimize transportation costs and ensure that the producers – small farmers – retain the profits of their labor.

The Charcoal Briquetting Process



Charcoal Drum (\$15) – converts agricultural waste into carbonized material for charcoal in a couple hours



Charcoal Press (\$2) – presses carbonized material into charcoal briquettes at speeds of up to 10-15 briquettes per minute. Briquettes pressed by hands crumble.

D-Lab is collaborating with community partners in many countries to ensure the product and process are affordable and meet the needs of the local population who will make and use the charcoal. The technology would not be where it is today without the community partners, who have contributed a number of innovations from the field, such as an easier method of lighting the drum using holes from below, a method of dousing the carbonized material with water to help settle the dust, and several versions of the charcoal press, including a charcoal press table that allows multiple people to make briquettes simultaneously. The evolution of the charcoal-making press has also been turned into a case study, showing how feedback from local users helped transform the device into a simple form that uses 90% less material, operates faster and cost 10 times less.

The Fuel from the Fields charcoal project was one of 22 winners (out of more than 2,000 entries) in the 2007 World Bank Development Marketplace Competition. As a result, more than 1000 local producers have been trained in the charcoal-making technique and 61 ateliers (or local workshops) for producing charcoal have been established in Haiti. The project has also been displayed at the Smithsonian Design for the Other 90% exhibit in 2007 and featured in numerous websites, radio programs, newspaper articles, magazines and books. D-Lab has also demonstrated the charcoal-making process in over 20 countries and developed materials to show people how to build each of the 3 pieces of charcoal-making equipment, teaching important skills for developing appropriate technologies in the process. Hundreds of students have participated in hands-on activities with charcoal, where they have an opportunity to learn how to use shop tools and equipment while producing useful charcoal-making devices that can be disseminated to community partners during field work trips.

By the Numbers



Projected deployed in 20+ countries, among them: Haiti, Pakistan, Ghana, El Salvador, Kenya, Thailand, Tanzania, Peru

More than 8 types of agricultural waste can be used: sugarcane, corn cobs and stalks, banana leaves, vetiver, sorghum stalks, coconut husks, cassava flour, millet stalks

1000+ local charcoal makers trained to date

61 charcoal ateliers (local workshops) established

Cost of equipment less than \$25

Payback period is less than 1 month

A bag of charcoal sells for US\$10 in Haiti

A farmer can increase his income by US\$500

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First Prototype
\$30
4-5 Briquettes a Minute

This one often got clogged up with material, and had to be cleaned out every three or four briquettes. So we redesigned it with a self-cleaning ejection mechanism. We also did a time-study in which we video taped several users and figured out how much time was spent on each aspect of the process. A lot of time was wasted picking up and putting down the hammer, so we redesigned it to optimize the tasks of each hand.



Second Prototype
\$20
6-8 Briquettes a Minute

This prototype worked slightly faster, but still had some issues. The door was sometimes difficult to close, and the ram rod got stuck sometimes during use.



Third Prototype
\$2
10-12 Briquettes a Minute

The third iteration drastically reduced the amount of material, was easier to construct, and sped up the process of producing charcoal.

"If you want to make something 10 times as cheap, remove 90% of the material"
-Amy Smith

Charcoal Process



1. Placing bagasse in the oil drum



2. Carbonizing agricultural waste by burning it in an oil drum



3. Carbonized bagasse



4. Crushing carbonized corn cobs into a powder



5. Mixing binder, water and charcoal to make briquettes



6. Pressing charcoal mixture into briquettes



7. The final product a beautiful briquette