How many sausages can you grill in the process of making 30g of biochar?

Demonstration of Carbon-negative cooking energy solutions at Biochar2010 Symposium (Bayreuth, Germany) by Christa Roth (FOODandFUEL consultant):

On the 8th July 2010 on the Biochar conference in Bayreuth (Germany) the answer was: at least 98 'Nürnberger' sausages in the time span of 40 minutes (which was when the supply of sausages came to an end, though the burner unit still ran for another 25 minutes before it had to be extinguished due to time constraints).

How the test was done:

1 	**2** 
A common 425 ml tin can served as fuel chamber, which was filled to a level of 70 mm with 200 g of standard 6mm pinewood pellets. A 10-mm layer of pellets soaked in paraffin (kerosene) was spread out evenly on top as lighting material (kindling) and lit from the top with a match to kick-start the pyrolysis process of the pellets in the fuel chamber.	After 1 Minute a 850 ml tin-can was slid over the firechamber as an after-burner unit. It features airholes and a concentrator disk to thoroughly mix preheated secondary air with the woodgas created by pyrolysis in the firechamber. Thus a clean combustion can be achieved. The flame was strong enough for the grill.
3 	**4** 
In this demonstration the flame of the afterburner was established already well enough after 2 minutes, to accommodate the skillet on top.	After one more minute the skillet was hot enough for the first sausages. The start-up phase is considerably shorter than if charcoal would have been used as a fuel.

In the duration of 40 Minutes 98 'Nürnberger Rostbratwürstchen' were prepared and served to the participants.
Due to lack of stock, the sausage grilling was stopped after 40 minutes and the griddle was removed from the fire to prevent overheating. The flame of the burner

continued for another 25 minutes without emitting smoke. It had to be stopped prematurely as it was time to leave the university compound. So the fire was put out and the remaining fuel quenched by putting the tight-fitting can over the top of the can lid screwed to the bottom of the bucket.
On the next morning the fuel container was emptied and it became apparent that the lowest 15 mm of pellets were still in its raw stage and had not been carbonized. This entails, that about 65 mm of the original 80 mm of fuel stack in the fuel container had been carbonised over a period of 65 minutes. This means a downward progression of the flaming pyrolysis front of 1 mm per minute.
As the test was aborted prematurely, there was no point in weighing the char yielded in the experiment. In an earlier experiment with identical set-up on the 6th July 55 g of biochar were obtained from 200ng of wood pellets (see photo). The burner unit was flaming for 80 minutes, which corroborates the burn-rate of that paritcular fuel of 1 mm per minute.

5 	6 
Results on 8.7.2010 in Bayreuth	Results on 6.7.2010 in Eschborn

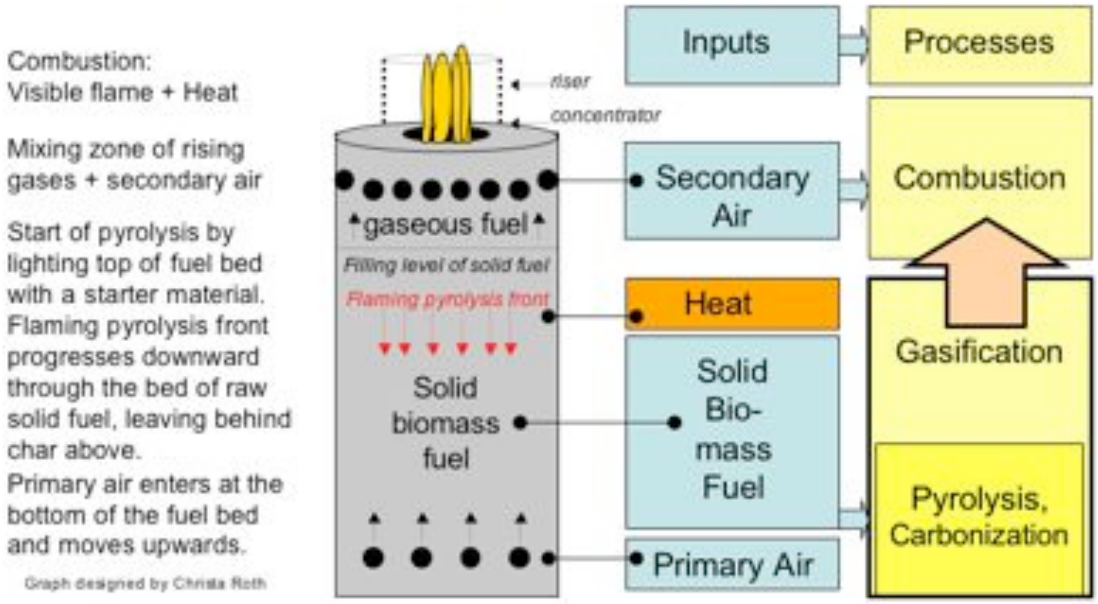
The burner-unit had been built inspired by instructions of the EverythingniceStove by WorldStove (do-it-yourself instructions http://worldstove.com/about-2/why-pyrolytic-stoves/ (on left edge of page). The page provides further reading on pyrolytic cookstoves.

Conclusion: Biochar can be produced with very simple devices as a byproduct of a cooking-process, that would anyhow happen: over 2 billion people cook their daily food on solid biomass fuels, using mostly inefficient open fire or simple devices with poor combustion and high smoke emissions. Pyrolytic gasifier cookstoves are currently the cleanest burning devices available to burn biomass under atmospheric conditions. With appropriate air-control the biochar yield can be 20-30 % in weight and 50% in volume of the original raw biomass.
The wood-gases obtained in the pyrolytic processes deliver thermal energy wehn combusted that can be used for cooking purposes.

Pyrolytic micro-gasifier can decentrally produce small amounts of biochar, as long as the raw biomass is dry and in suitably sized chunks of 5 to 50 mm. This allows the use of small-size biomass residues from agriculture, forestry or agro-industry, which could otherwise not be used as cooking fuels in conventional cookstoves. As it makes only limited sense to chop down timber-sized wood to fit into a gasifier fuel container, for so-called 'stick-wood' other efficient cookstove technologies are recommended.

Technology: Top-lit up-draft (TLUD) microgasifiers are specifically suitable for cooking-purposes, as the combustion of the generated wood-gas happens close-

coupled above the gas-generation zone. Thus sequestration or cleaning of the wood-gas can be avoided.
The principle of TLUD micro-gasifiers was first developed by Tom Reed (USA) and Paal Wendelbo (Norwegen) in the 1980ies and since refined:



Restricted primary air supply suppresses the complete conversion of the raw biomass to ash. The process is 'arrested' after the pyrolytic conversion from raw biomass to char and woodgas. The char remains due to the lack of oxygen for its combustion. The hot woodgas containing combustible pyrolytic vapours and gases rises through the char and can be cleanly combusted if well-mixed with an appropriate supply of secondary air above the stack of solid fuel.
The flaming pyrolysis front sustains the heat needed for the pyrolysis by partial combustion of the created gases, restricted by the limited amount of available oxygen. The front progresses downward through the solid fuel stack, in the case of 6 mm diameter woodpellets about 1 mm per minute. Temperatures reached are between 450 and 600 ° Celsius. The quality of the biochar highly depends on the temperature and the speed of the conversion process, which is controlled by the available air. This can be influenced e.g. by the amount and flow rate of air which is a function of the created draft (either with a chimney in the case of natural draft or a fan/blower with forced convection). When no raw fuel is left to convert, quenching the hot char by cutting off all air supply to avoid the conversion to ash should result ideally in a deep-black biochar. If this biochar is incorporated into the soil and not combusted for energetic purposes, the cooking-process becomes carbon-negative.

Outlook: A manual on microgasifier cookstoves is currently being compiled by the German sector programm 'Poverty oriented basic energy services' commissioned to the German Technical Cooperation (GTZ) by the German Ministry for Economic Cooperation and Development. Publication is planned for later in 2010.

Summary: *Small-scale biochar production as a by-product of daily cooking with biomass: Pyrolytic micro-gasifier burner units can turn cook-stoves into clean-burning, efficient and carbon-negative thermal energy applications, while alleviating many other problems originating from conventional use of solid biomass cooking fuels like indoor air pollution, black carbon emissions, forest degradation and other environmental issues.*

Authored by: Christa Roth, consultant for FoodandFuel, Eschborn, Germany, christa-roth@foodandfuel.info