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**FEBRUARY 14-17, 2005**



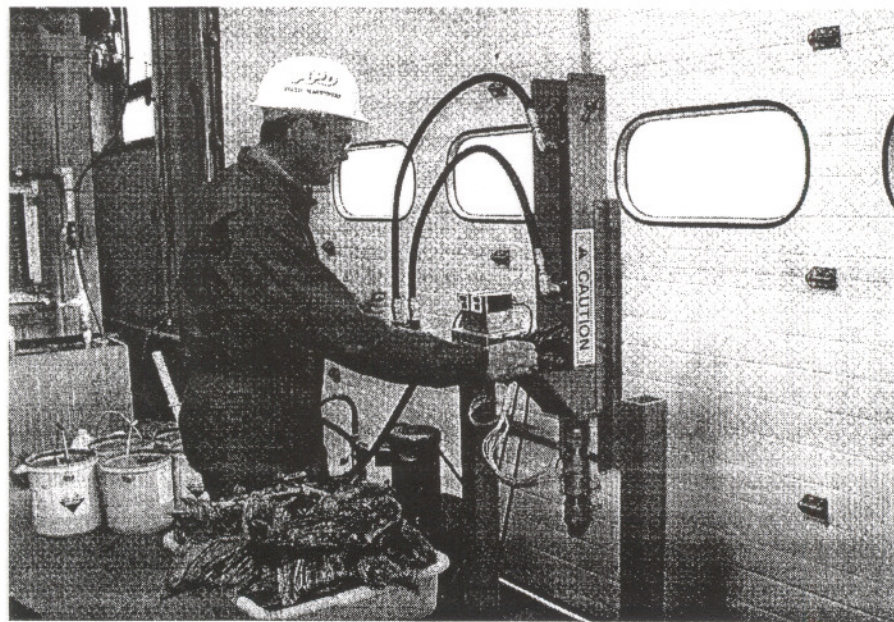
# HEATING GREENHOUSES WITH PLASTIC: CLEAN HEAT FROM DIRTY WASTES

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Recovering valuable energy from most types of plastic wastes may soon become reality. Dirty, used or non-recycled plastics can be converted to heat for greenhouses and agricultural operations, commercial buildings, light industrial facilities, or other buildings requiring an environmentally clean, yet safe, fuel. Here are two technologies being worked on at Penn State University.

## The First Technology: Plastofuel

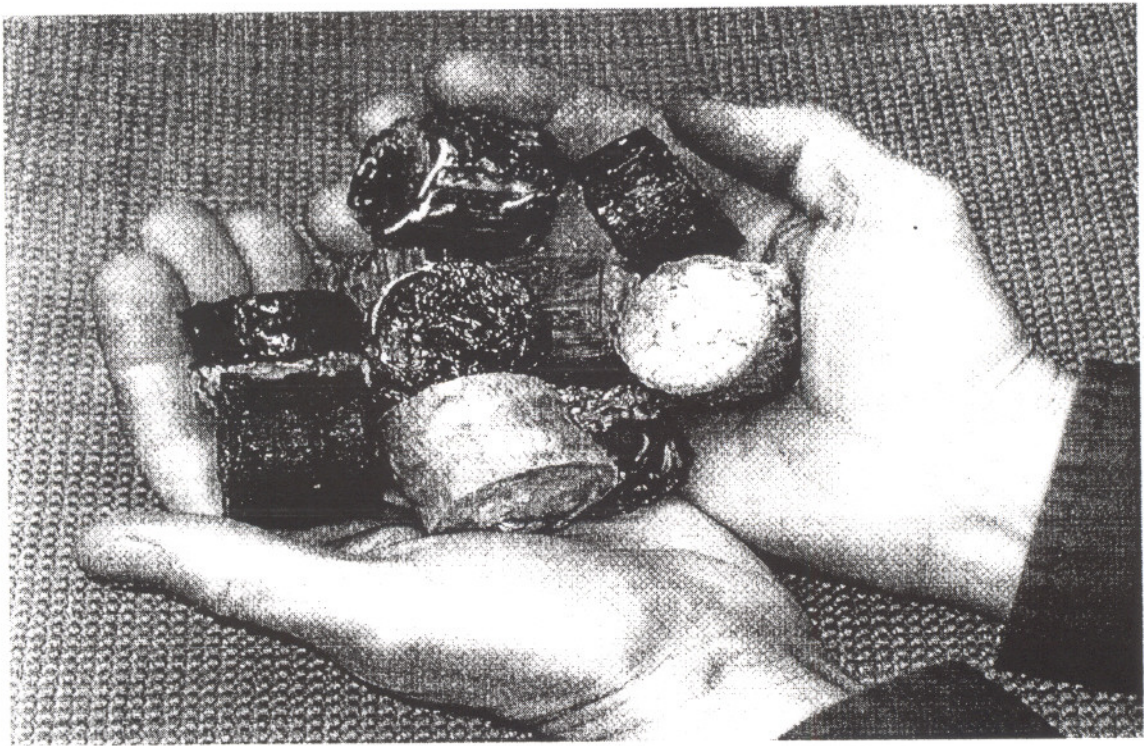
A simple process has been invented to densify waste plastics into a fuel, called Plastofuel. This process was developed in the Department of Agricultural and Biological Engineering at



Penn State University, with the goal of reducing waste plastic buildup on farms around the world. The process works by forcing rigid or film plastic items through a heated die, thus melting a thin jacket which encapsulates the pieces of plastic and dirt within the extruded material exiting the die. A hot knife cuts the extrudate into dense fuel nuggets that can be easily conveyed, stored and shipped.

**Figure 1.** Shown are very dirty plastic drip irrigation tubing and mulch film being fed by hand into the prototype Plastofuel machine. A hydraulic cylinder forces the plastic items through a heated die, shown on the lower right. The extruded material is then cut with a hot knife to form Plastofuel, shown in Figure 2.





**Figure 2.** These Plastofuel fuel nuggets were made from all sorts of dirty plastics mixed together. The process works well using either discarded films, rigid plastic items, or both.

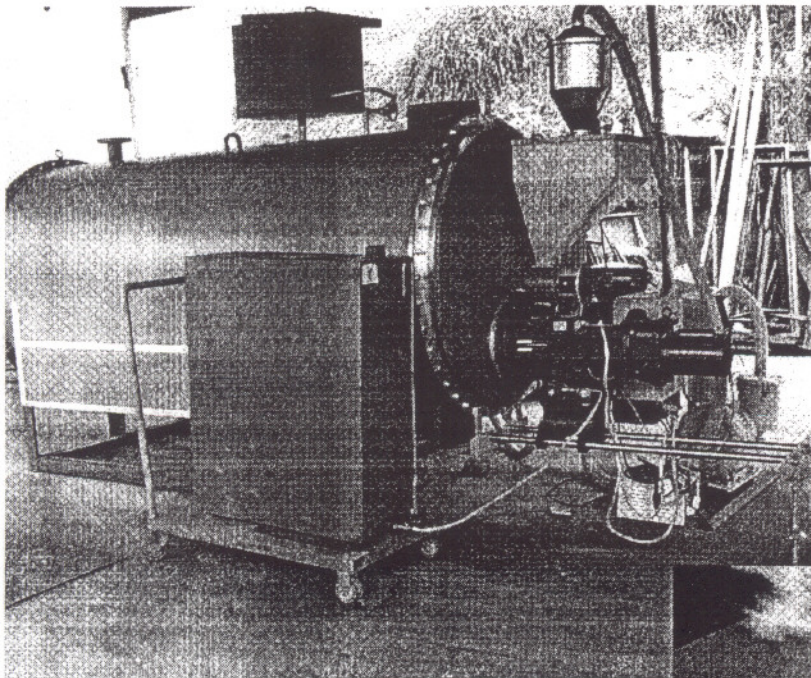
The nuggets were originally designed to be co-fired 5-10 percent with coal in existing boilers, allowing the high temperature of coal (around 2000 °F) to sustain clean combustion, free of noxious smoke. The end-use is for agricultural boilers or small community boilers designed to burn coal. Plastofuel can be made either on the farm or in small industrial settings, thereby consuming the energy close to the source. The benefit of the system is that it converts an annoying waste into a valuable fuel, with a minimum of energy expended in the process. Non-recycled consumer plastic food and beverage containers can also be used in the process.

Beginning in 2005, the Penn State team will scale-up the prototype Plastofuel process to produce 227 kg (500 lbs.) per hour. This system will be instrumented to measure energy expenditures, which will better define the economics of the process compared with competing fuels. It will also provide Plastofuel in quantity for pilot-scale testing.

#### The Second Technology: Korean High Temperature Combustion

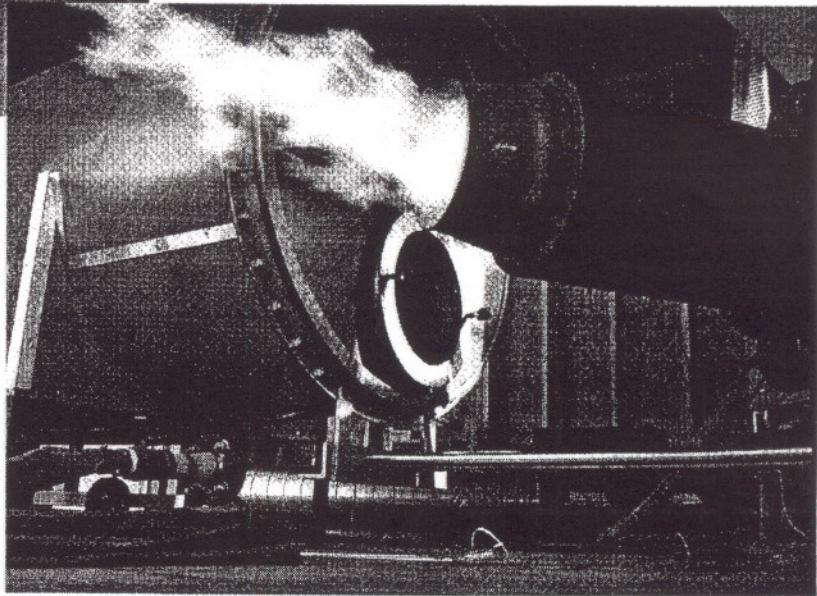
Although blending used plastic with coal continues to be an important way to recover energy from waste plastic, a new Korean technology is being investigated by researchers at Penn State. Manufactured by GR Technologies Company, Ltd., this hot water boiler heating system burns pea-sized pellets made from waste plastics. The system preheats a series of combustion chambers to 1650-2000 °F (900-1100 °C) for 10-15 minutes using fuel oil or kerosene, then automatically switches to the plastic pellets. Field testing of a 396, 850 Btu/hr. (100,000 kcal/hr.) unit for heating high tunnels began at the Horticulture Research Farm in 2004. Eventually, the pellet-fueled unit will be modified to burn the larger and more energy efficient Plastofuel nuggets.





**Figure 3.** Shown is the GR Technologies boiler at the factory in Korea. The rectangular tank in the foreground stores the fuel oil for pre-heating. The boiler is the cylindrical piece on the left behind the fuel tank. The high-temperature burner is shown on the right, fueled by plastic pellets conveyed by a vacuum feed device to the hopper atop the burner. The electronic control box is partially visible behind the burner.

**Figure 4.** This is the hot water boiler housed in the boiler building at the Horticulture Research Farm. Hot water heated by the unit is used to heat high tunnels nearby. Here, the burner (right) has been pulled out of the boiler (left) for demonstration purposes to show the flame while burning plastic fuel.



Testing by the Korea Test Laboratory showed this system meets Korean and US Environmental Protection Agency (EPA) emissions standards. To verify EPA test results in a field setting, in 2005 researchers will investigate combustion characteristics and efficiencies, air emissions, and overall system heat transfer using a wide array of waste plastic fuels.