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Resource

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Warming Up to Plastics

Pollutionbuster Crops

Members Vote on Name Change

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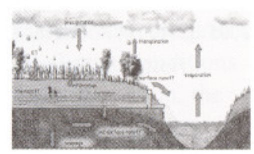

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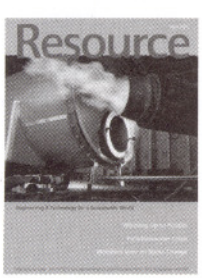

Jim Garthe takes the heat — not *for* but *in* his research. His photography also dramatically captures the heat – of a hot water boiler housed in the boiler building at Pennsylvania State University's Horticulture Research Farm. On the cover, the burner (at right) has been pulled out of the boiler (left) for demonstration purposes to show the flame while burning plastic fuel. Hot water heated by the unit is used to heat high tunnels nearby.

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Heating with Plastics

Clean heat from dirty wastes

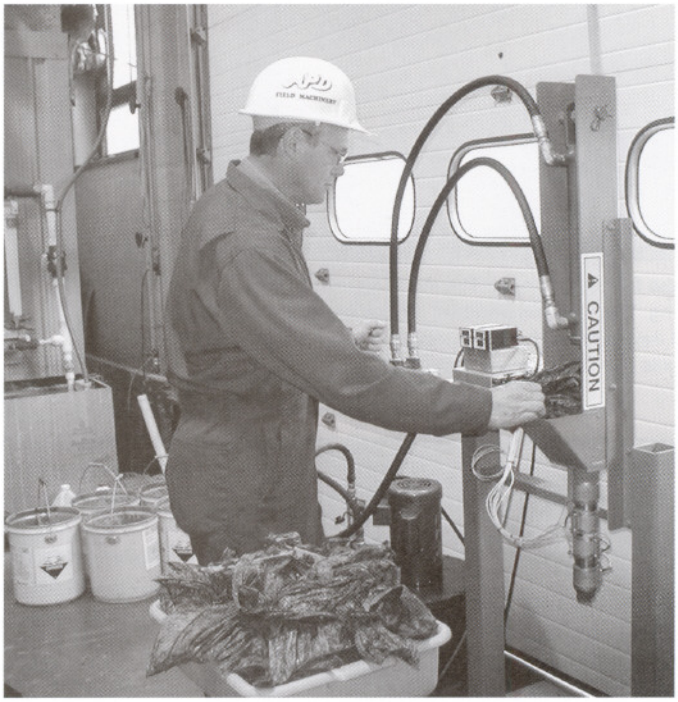
James Garthe

Recovering valuable energy from waste plastic items used in agriculture 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. Two fuel-saving technologies are currently being investigated by a research team at Penn State University.

The first technology: Plastofuel

A simple process called Plastofuel was invented in 1995 to densify waste plastics into fuel nuggets. The process, developed in the Department of Agricultural and Biological Engineering, aims to reduce waste plastic buildup on farms around the world. It works by forcing rigid or film plastic items through a heated die, thus melting a thin jacket that 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.

The nuggets were originally designed to be co-fired 5 to 10 percent with coal in existing boilers, allowing the high temperature of coal (around 1,100°C/2,000°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.



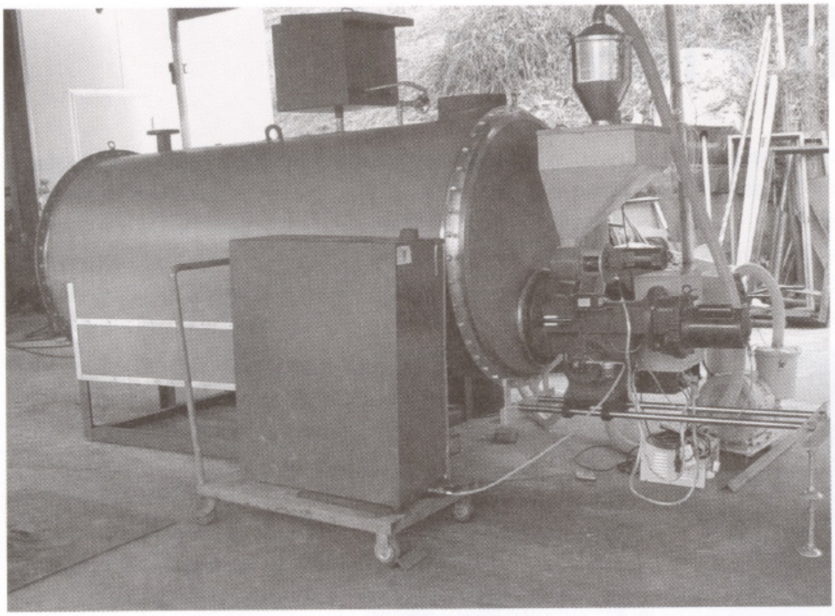
James Garthe feeds mulch film made from very dirty, plastic drip irrigation tubing into the prototype Plastofuel machine. A hydraulic cylinder forces the plastic items through a heated die, shown on the lower right. The extruded material is then cut with a hot knife to form Plastofuel, shown below.

Plastofuel nuggets are made from various types of dirty plastics mixed together. The process works well using either discarded films (e.g., mulch, greenhouse, or forage), rigid plastic items (e.g., pots, trays, or flats), or both.

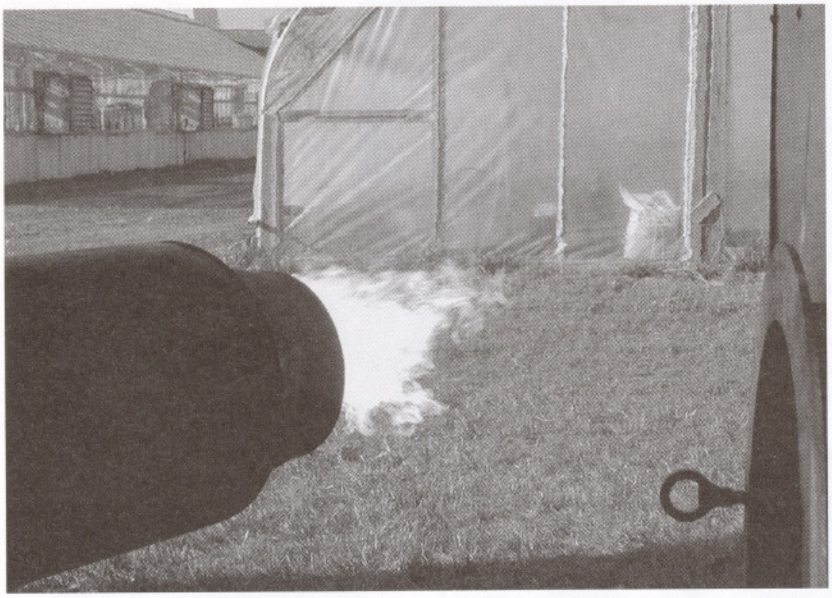
This year, the Penn State team will scale-up the prototype Plastofuel process to produce 227 kg/h (500 lb/h). This system will be instrumented to measure energy expenditures, which will better define the economics of the process compared with competing fuels. It will also provide Plastofuel in quantity 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 the team members. Manufactured by GR Technologies Company, Ltd., this hot-water-boiler heating system burns pea-sized pellets made from waste-mulch film plastic. The system preheats a series of combustion chambers to



Here is the GR Technologies boiler at the factory in Korea. The rectangular tank in the foreground stores fuel oil for preheating. The high-temperature burner fueled by plastic pellets conveyed by a vacuum feed device to the hopper atop the burner is shown on the right. The electronic control box is partially visible behind the burner.



This clean-flame burner will be used to heat the high tunnel in the background and, eventually, the greenhouse to the left. For public safety reasons, emissions testing will be conducted to assure that U.S. Environmental Protection Agency air quality standards are met. Fuels tested will be locally produced granulated plastic drums and fuel pellets made from used plastic mulch, made in Korea.

900-1,100°C (1,650-2,000°F) for 10-15 minutes using fuel oil or kerosene, then automatically switches to the plastic pellets. Field testing of a 396, 100,000 kcal/h (850 Btu/h) 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.

Specifications for the unit being tested

Preheat fuel: 1.5 L (0.4 gal) kerosene or fuel oil for 10-15 minutes

Fuel: For 20 seconds after preheat, burner dual-fuels with kerosene and plastic, then plastic thereafter indefinitely

Pellet types: Burns polyethylene (#2, #4) or polypropylene (#5)

Note: Polystyrene (#6) & ABS pellets require a 50 percent barrel length increase, currently not available

Plastic fuel feedrate range: 9-15 kg/h (20-33 lb/h)

Current plastic fuel feedrate: 13 kg/h (29 lb/h)

Dioxin (PCDD/F) emissions: 0.119 ng-TEQ/sm^3 @ 12 percent O_2 as confirmed by Korea Testing Laboratory

Note: U.S. EPA allows 5.0 ng-TEQ/sm^3

Boiler type: Circulating hot water

Rated capacity: 100,000 kcal/h (396,850 Btu/h) on 9 kg/h (19.8 b/h) with 11,500 kcal/kg (20,686 Btu/lb) plastic fuel pellets

Thermal efficiency: 75 percent; at 150°F water, thermal efficiency goes to 89 percent

Combustion chamber operating temperature: 900-1,100°C (1,652-2,012°F)

Boiler cut-in temperature: 60°C (140°F)

Boiler cut-out temperature: 80°C (176°F)

Boiler heating cycle: 5 h comprised of 2 h burning and 3 h circulating

Boiler heating rate: 1 ton water requires 45-min-heating time (entire heating system will hold 3 tons of water with 2-h heating time)

Power needs: 4 kW@110 vac with 208 vac for vacuum fuel supply

Future boiler, sized for Plastofuel: 2,000,000 kcal/h (7,937,000 Btu/h)

Testing by the Korea Test Laboratory showed that this system meets Korean and U.S. Environmental Protection Agency (EPA) emissions standards. To verify EPA test results in a field setting, this year researchers will investigate combustion characteristics and efficiencies, air emissions, and overall system heat transfer using a wide array of waste plastic fuels. To be a commercially viable system in the United States, the researchers stress that conforming to EPA emissions standards is paramount. R

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