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One man's trash...

When landfills overflow, governments need new ways to deal with garbage. **David Cyranoski** visits a plant in Japan where plasma technology is turning waste into energy.

Michiaki Shigehiro has a rare problem. "I've struggled to find enough garbage," he says, in dead seriousness. He already sees a lot of waste, on average 100 tonnes per day, but he'd be far happier with twice as much.

Shigehiro is general business manager of EcoValley Utashinai, a company named after a remote city in Japan's northern island of Hokkaido. EcoValley converts heaps of refuse into energy using a plasma arc, a jolt of electricity that ionizes gas in a chamber and produces temperatures of up to 16,000 °C, or almost three times hotter than the Sun's surface. The technology is costly and must process massive amounts of trash to recoup EcoValley's ¥7-billion (US$59-million) investment.

Utashinai city may not generate enough waste, but the rest of Japan, and the world, generally churns out too much. Every year, Japan produces about 50 million tonnes — about one kilogram per person per day — of paper, food, plastics and other garbage collectively known as municipal solid waste (MSW). The United States is almost twice as wasteful per capita, generating a total 222 million tonnes in 2005. Most of the time MSW is either stuck in a landfill or burned at a considerable cost to the taxpayer as well as releasing pollutants into the soil or air.

Americans pay between US$30 and US$80 per tonne, depending on the region, to dump their trash in landfills and US$69 per tonne on average for incineration. In a small country such as Japan, where land is more scarce, local governments pay US$200–300 per tonne to local landfills and incinerators. Landfills and incinerators also have knock-on economic effects, such as lowering property values nearby and, when improperly handled, may create environmental hazards.

The planners behind EcoValley Utashinai thought they could solve all these trash problems at once using plasma-arc technology. In theory, waste disposal would become a profitable and environmentally benign business by converting gasified waste into energy. On paper, MSW contains one-third to one-half the energy of coal per tonne — enough to power a plant and sell excess to the national grid. But the Utashinai plasma plant is the only major energy-recycling MSW facility in operation, and it has struggled to make ends meet since opening in 2002.

Several companies, betting that they can improve on the Japanese experience, are planning their own plasma-arc facilities. Atlanta-based Geoplasma is finalizing a contract for a plant more than 10 times the size of Utashinai to be built in St Lucie, Florida, a wealthy community where a massive landfill has lowered property values. If it succeeds, by 2009 it would be processing 2,700 tonnes of waste per day. And in September, Startech Environmental based in Wilton, Connecticut, announced a contract for a 180-tonne-per-day plant in Panama. Plasco Energy Group of Ontario is negotiating similar-sized plants in Ottawa and Barcelona.

ST LUCIE COUNTY SOLID WASTE

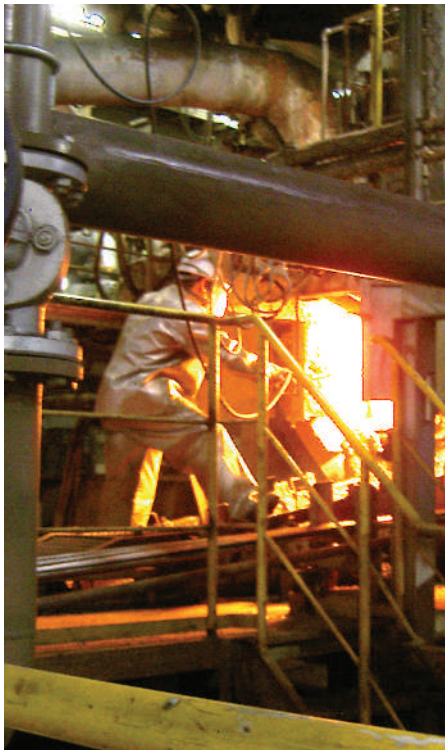
Ron Roberts, left, believes plants using plasma technology can remove an ugly landfill in Florida.

Torching garbage

If these plants are built, it will be a vote of confidence for plasma arc, which despite its promise has not yet turned trash into gold. Those in the industry are optimistic. According to Hilburn Hillestad, Geoplasma's president for environmental affairs, the technology will catch on because of a "perfect storm of forces" — which includes increasing political and public attention on pollutants and rising energy prices.

Plasma arc is an old technology, although its use in large-scale waste disposal is new. Since the 1960s, NASA has used it to simulate the high temperatures faced by space vehicles re-entering the atmosphere. Now plasma torches are used widely for melting scrap metal or destroying hazardous materials. But it wasn't until the early 1990s that companies such as Startech and Westinghouse Plasma in Madison, Pennsylvania, which builds the plasma arcs used by Geoplasma, began developing torches for trash.

The torch is created by ionizing the air in a chamber with a powerful electric arc to generate plasma, which is then used to heat MSW, coke and limestone in a second oxygen-starved chamber. Under these conditions, the plasma torch heats the mixture to temperatures above 1,500 °C that enable it to vitrify inorganic materials in MSW without combustion occurring. The innocuous slag that results can be used as a



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Burn out: a plasma torch gasifies municipal waste, which is used to power a steam turbine at Utashinai.

construction material, although it doesn't fetch a high price.

More importantly, the heat breaks down organic molecules in the MSW. Whereas combustion generates lots of carbon dioxide, in an oxygen-limited environment the MSW is converted to a mixture of mostly carbon monoxide and hydrogen, called syngas. Syngas can be used like natural gas to power a gas turbine. Purified hydrogen could itself be used as fuel. The gas mixture is further processed to minimize the amount of other pollutants, such as nitrogen oxides and dioxins, that enter the turbine or escape into the atmosphere.

The Japanese have had some success with this technology. Utashinai's plant pumps out 3,000 megawatts of power per year, all of which is used to run the plant. But its supply of trash is dwindling. With a population of 5,500, Utashinai holds the title of Japan's smallest 'city', an appellation it earned 50 years ago when 45,000 people lived there. Rather than respond to a trash crisis, the plasma-arc plant was intended to spur the local economy by charging fees for waste disposal, which it does, and selling electricity and slag, which it does not.

On average, the plant only processes 60% of trash volume that the company expected. The facilities also suffer operational problems, though not with the plasma torch itself, and one of the two lines is often down for maintenance. When the lines are running at full capacity, there may not be enough trash. At other times, the facility turns it away.

Getting more trash from elsewhere is one option. But few citizens want their home to become a dumping ground or processing plant for trash from other areas. "No one has a good image of garbage," says Shigehiro. Some states in the United States will import garbage, collecting lucrative tipping fees. Big cities such as New York and Toronto export most of their waste for processing. But in Japan there is little trade in trash, local governments prefer to process waste locally than dump it elsewhere.

In Florida, St Lucie county already has a 4.3-million-tonne landfill in their backyard. Clearing that would open up 160 acres of land and increase local property values. Geoplasma will process 1,800 tonnes of new trash and 900 tonnes of landfill trash everyday, emptying the site in less than 20 years — the time Geoplasma says it will take to recoup its US$425 million investment. Hillestad says 80% of their income will come from energy sales. The company expects to produce 160 megawatts per day, of which 120 will be sold off.

"No one has a good image of garbage."
— Michiaki Shigehiro

Trash trade

One difference between the St Lucie and Japanese plants that may allow higher energy output will be the use of a gas turbine, a device that turns syngas into electrical energy. The Utashinai plant uses a substantially cheaper steam turbine that can only convert about 15% of the energy to electricity. Geoplasma will use a $40 million gas turbine that is almost 40% efficient.

This higher efficiency should help it to generate more energy from their syngas. But the Utashinai syngas contains small amounts of hydrogen chloride and sulphur oxides, says Shinichi Osada, head of the environmental systems division at Hitachi Metals, which installed the Utashinai plant. "These might attack a gas turbine," explains Osada. With a steam turbine, the gas heats water, creating steam for the turbine. In a gas turbine, the gas flow itself turns the turbine — a more efficient process, but one which potentially exposes the machinery to any corrosive gases. Indeed, Utashinai had a gas turbine from a previous project and Hitachi decided to replace it with steam turbines for fear of degradation.

Geoplasma says that, in Florida, pretreatment will reduce the amounts of corrosive gases to acceptable levels. "The scale of the St Lucie plasma plant allows for the investment in higher technology processes in order to avoid such problems," says Hillestad.

When bidding for local government contracts, plasma companies have to compete with other waste-disposal options. Some of these also promise a measure of converting waste into energy, or lower levels of pollutants. "We researched incineration, anaerobic digestion, gasification, plasma-arc gasification, bio-reactors, and alternative landfilling methods," says Ron Roberts, assistant solid-waste director of St Lucie county. The result: a 6,000-page report and a conclusion that there was only one proven solution to the MSW problem that would end the need for a new landfill. "The solution was plasma-arc gasification," says Roberts.

Getting rid of the landfill was a key factor in St Lucie's decision. Geoplasma, too, needed the landfill to guarantee it enough trash. Once the landfill is gone, the company may have to close the plant, depending on the size of the regular trash supply, but they should have recouped their installation costs by then. A lack of steady trash was one reason that Geoplasma's plan to establish a plant in Hawaii failed. The local government would only guarantee 300 tonnes per day. "It was not enough for us to compete with rates of existing incineration plants," says Hillestad.

Although few could argue against removing an ugly landfill, environmental groups remain wary about trace pollutants in syngas. In a 2006 report on thermal conversion strategies for MSW, California-based Greenaction for Health and Environmental Justice calls plasma-arc and other high-temperature gasification technologies "incinerators in disguise".

The Utashinai plant says it has met all of Japan's stringent environmental standards (although it has yet to undergo the regional government's audit). Still Shigehiro is sceptical that the technology will catch on: "Many foreigners come to see our plant, but no one builds their own," he says. Roberts, who has visited Utashinai, is far more upbeat. "We are not worried about it being too good to be true. We have seen the process in operation," he says. "We certainly hope that Geoplasma has done its due diligence on the economic side of the equation." The test of that will be St Lucie. ■

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