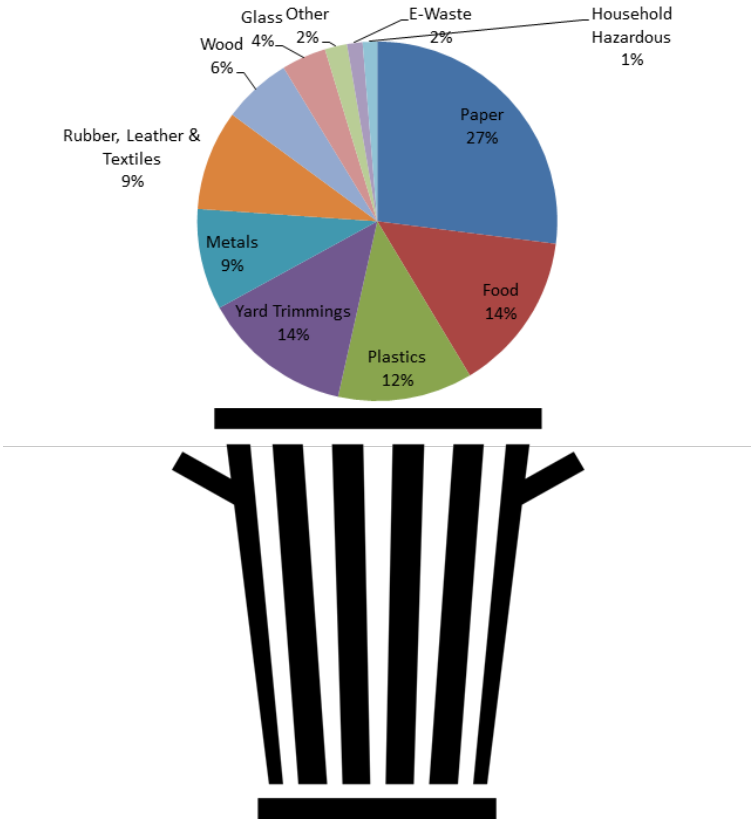
The Wonderful Life

Congratulations to the Midwestern city of Bedford Falls voted “Best City of 2120”, where the 255,483 citizens experience what they call “The Wonderful Life.” Beautiful bluffs and terraces rise two hundred feet above the river banks. Temperatures range between 20° and 90° Fahrenheit and the city receives 40 inches of annual precipitation. Famous landmarks include Wainwright Tower and the George Bailey Memorial Bridge. Bedford Falls, an inland port, thrives as a regional hub of commerce. Clarence State University beckons a diverse population. The Waste Recovery Research Division makes Bedford Falls an international leader in Waste to Energy (WtE), the city’s power source. Crime is low due to a robust economy and a top rate police department, utilizing emergency safety drones. The fire department is the best in state due to fire suppression technologies, emergency medical services, and public education. The city’s broadband infrastructure, designed by systems engineers, extends to all outdoor spaces and public transportation. Bedford Falls is a midpoint stop between Washington DC and Los Angeles on the transcontinental bullet train. Clean, autonomous vehicles allow for a green commute in and around the city on LED directional roads developed by civil engineers. Schools achieve goals and have strong accountability. Riverfront communities offer shared amenities, such as biking trails and vibrant parks. Popular sports include ice hockey, swimming, and rowing. Local farmers markets, convenient cafes, and retail allow for a walkable city. City services exceed resident's needs and community involvement allows empowered citizens to take pride in their growing city.

The Problem

Growth lead to more waste, which developed into a transportation, landfill, and processing problem. Civil engineers of the Municipal Solid Waste (MSW) department were faced with an average of 4.4 pounds of trash per person, per day.

Types of Trash



Trash spilling into the streets littered the city. Waste Management (WM) trucks congested the roads as they collected trash and recyclables from commercial and residential areas. More trucks on the road meant more pollution, accidents, and noise. WM trucks were expensive to maintain, had a negative environmental impact, and were not energy efficient. Trucks continued to haul to the overflowing landfills. Water pollution, chemical exposure, and

habitat destruction were some of the environmental problems associated with the landfills. WM trucks also hauled recyclables to the Materials Recovery Facility (MRF). Without a citywide informative recycling program, daily trash was disposed of incorrectly, causing a contamination rate up to 40 percent. Correctly recycled items were separated by high maintenance shake tables, magnetic separators, fans, optical scanners, and hand picking. Processed and baled recyclables were transported by large trucks to manufacturing facilities for use in new products.

The Plan

A multi-disciplined group of engineers from the local university were commissioned to solve the solid waste problem. With no plan being perfect it was time to revise the Four R's program. A citywide solid waste management system which was safe, environmentally sound, and energy efficient for residential and small businesses was created. A project plan was drafted to keep the solution on schedule and became Bedford Falls' vision for The Wonderful Life.

Reducing residential and commercial waste began with the development of new materials which reduced unnecessary and costly single-use packaging. Biochemical engineers at Wainwright Plastics developed biodegradable plastic from locally grown corn plants in a controlled vertical indoor environment using a rockwool rooting medium. Biodegradable packaging, withstanding temperatures up to 150°, is used for many products such as disposable water bottles, food containers, grocery bags, and other single-use packaging. Value is created by reusing these products to make 3D printing filament. 3D printing is available in every home allowing consumers to print disposable packaging when needed, in turn, encouraging behavioral changes. Consumers buy less, use less and make wise packaging choices.

Through their reverse study of silk in nature, biomedical engineers developed engineered silk made of fibroin protein and water. Engineered silk is used as an innovative

packaging that reduces waste from single use items such as hotel shampoo, disposable cups, and plasticware. In the medical field, this product is useful for screws and pins to set broken bones. The silk biodegrades in the body as the bone heals. Engineered silk is versatile, safe and renewable.

Reusing parts from discarded products and repairing instead of replacing saves resources and lowers production costs in new manufacturing. Discarded e-waste is returned to the retailer. Larger products are picked up by the manufacturer. Processing includes refurbishing or dismantling for valuable parts. Today, products are more durable and last longer because the manufacturer assumes responsibility that does not end with the sale of the product but lasts to the end of the product's lifecycle.

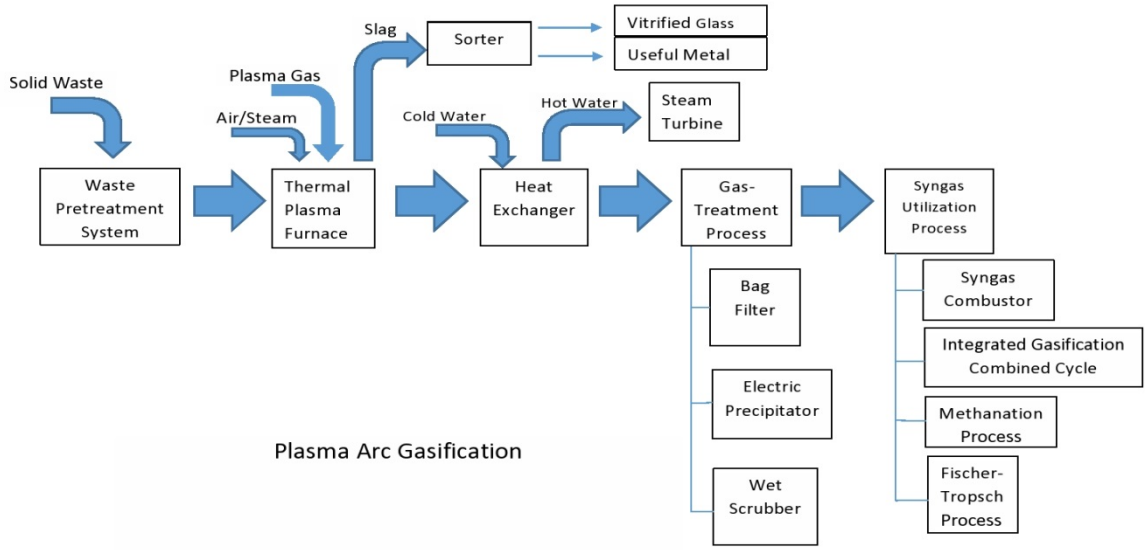
Recycling residential and commercial items is convenient thanks to biodegradable engineered silk nanochips. Nanochips embedded in recyclables are read by scanners in reverse vending machines to identify materials, making sorting fast and accurate. Therefore, complicated and sometimes dangerous sorting is eliminated. There is no added expense associated with contaminated items. Recyclables are deposited by citizens at conveniently located, reverse vending machines where scanners aid in self-sorting. Efficient machines grind and compact the material for pick up. Recycling reduces the cost of producing new products, creating a more circular economy. An educational program with age appropriate curriculum is provided to schools. Small businesses and community centers display signage and recycling bins with easy, clear instructions.

Recovering value from non-recyclable feedstocks was achieved by chemical, mechanical, energy, and electrical engineers who designed, tested, and implemented the construction of the plasma arc gasification (PAG) unit. The principle of gasification is that matter

cannot be created or destroyed; therefore PAG breaks down any carbon containing waste to its basic elements creating syngas. The Fischer-Tropsch process, a catalytic chemical reaction, converts syngas to liquid fuels. According to the chemical equation:

$$(2n+1)\ H_2 + n\ CO \rightarrow C_n\ H_{(2n+2)} + n\ H_2O$$

The gasifier is fed non-recyclable MSW including household hazardous and toxic waste. During this treatment waste materials are broken down into small pieces and shredded to increase the surface area to volume ratio making the heat transfer more effective. Gasifiers operate at high temperatures without oxygen. Due to the lack of oxygen, trash is not burned, it is vaporized. Trash is transported by smaller, CNG trucks (operating on converted syngas) requiring fewer trips and is gasified by the city owned facilities. PAG byproducts are slag and energy rich syngas which can be converted to electricity, liquid fuels, hydrogen, synthetic natural gas, polymers, heat, and steam. Slag is used to make rockwool and building materials. Gasification significantly reduces harmful emissions including 95% of mercury and sulfur dioxide, 60% of

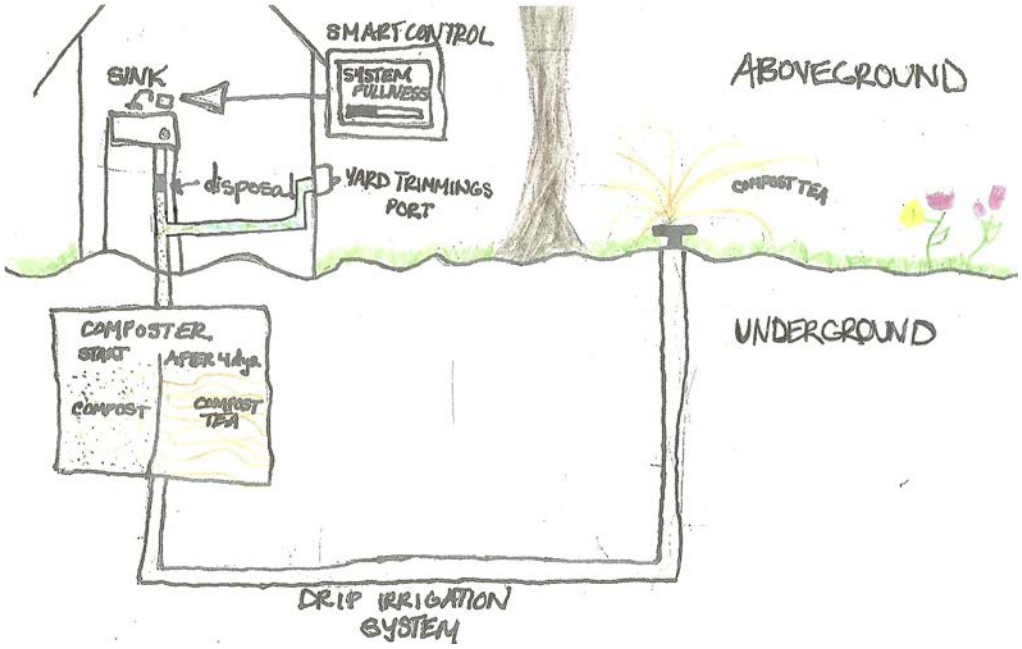


Plasma Arc Gasification

nitrogen oxide, carbon dioxide, and carbon neutral biomass.

Rotting of organic matter and returning it to the earth is achieved by Anaerobic Digestion (AD). AD is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. AD appliances were developed by mechanical and chemical engineers for residential and commercial use. The garbage disposal's strong blade grinds all food waste and sends it to a digester. Yard trimmings are added to the digester from a separate port. Intelligent controls monitor the digestion process, adjusting pH and adding necessary enzymes to enhance the naturally occurring microorganisms. The continuously fed digester produces a rich, organic composting "tea." The "tea," distributed over the landscape through a drip irrigation and sprinkler system, allows optimal nutrients to be returned to the land. The digester produces an organic material that eliminates the need for harsh chemicals and fertilizers creating lush green spaces in Bedford Falls.

Anaerobic Digestion Process



Benefits of the 5 R's Solution

- Energy efficient
- Regional energy solution
- Provides fixed cost non-volatile energy
- Fuel flexibility
- Operates 24 hours/7 days a week
- By-product revenues
- Environmentally sound

Risks to the 5 R's Solution

- Buy-in from citizens
- Requires correct ratio of MSW to create syngas

The tradeoff of implementation costs is offset by the potential for revenue from the WtE process. Importing non-recyclables on river barges provides an additional revenue stream.

Bedford Falls solid waste solution promotes a sustainable lifestyle but must remain dynamic. The current framework includes a clean, energy producing PAG facility in the industrial zone. Throughout the zone are solar powered, carbon-scrubbing, artificial trees that create clean air by removing carbon dioxide and releasing oxygen. Advancing PAG technology is achieved through research grants. PAG appliances are being launched in businesses and residential zones further reducing WM traffic. Tax incentives are available for first-time PAG, AD, and 3D printing appliance purchases.

Resource efficiency, sustainable consumption patterns, and educational awareness engage the citizens who make smart choices about the way they live and what they consume. All the choices and actions, no matter how small, add up to an important balance with nature and the environment allowing citizens to enjoy the wonderful life in Bedford Falls.

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Bibliography

"3D Printed Solar Energy Trees." *AENews*. AENews, 28 Feb. 2015. Web. Oct.-Nov. 2015. <http://www.alternative-energy-news.info/3d-printed-solar-energy-trees/>.

"About Anaerobic Digestion." *Harvest*. N.p., 20 Mar. 2015. Web. 18 Nov. 2015. <http://www.harvestpower.com/clean-energy/about-anaerobic-digestion/>.

Alter NRG, Plasma Gasification - TheNewEnergy. Prod. AlterNRG. *YouTube*. N.p., 13 May 2009. Web. 15 Oct. 2015. <https://youtu.be/NrYJof510NU>.

Atteberry, Jonathan. "Are Food-based Plastics a Good Idea?" *HowStuffWorks*. HowStuffWorks.com, n.d. Web. 18 Oct. 2015. <http://science.howstuffworks.com/food-based-plastics.htm/printable>.

"Biogas Developers - The Anaerobic Digestion Process"" *Biogas Developers - The Anaerobic Digestion Process"* Biogas Developers, n.d. Web. 18 Oct. 2015.

Byun, Youngchul, Jaewoo Chung, Moohyun Cho, and Soon-Mo Hwang. *Thermal Plasma Gasification of Municipal Solid Waste (MSW)*. N.p.: INTECH Open Access, 2012. Print.

Carmody, Tim. "Wi-Not? South Korea's Seoul To Blanket The City With Free Wi-Fi." *Fast Company*. Fast Company, 31 Dec. 1969. Web. 18 Oct. 2015. <http://www.fastcompany.com/1760834/wi-not-south-koreas-seoul-blanket-city-free-wi-fi>.

Co, Alex. "Turning Trash into Gas: The Future of Plasma Gasification." *Yale Scientific Magazine*. Yale Scientific, 3 Apr. 2014. Web. 16 Dec. 2015.

"Could Plasma Gasification Virtually Eliminate the Need for Landfills?" Web log post. *Hometown Dumpster Rental*. Hometown Dumpster Rental, n.d. Web. 15 Oct. 2015. <http://www.hometowndumpsterrental.com/blog/could-plasma-gasification-virtually-eliminate-the-need-for-landfills>.

De Klerk, Arno. "Kirk-Othmer Encyclopedia of Chemical TechnologyPublished Online: 18 JAN 2013." *Fischer–Tropsch Process*. Wiley Online Library, 18 Jan. 2013. Web. 16 Dec. 2015.

"Firefighting in the U.S. – 100 Noteworthy Fire Departments » Online Fire Science Degree." *Onlinefiresciencedegreeorg*. N.p., n.d. Web. 18 Oct. 2015.

Freudenrich, Ph.D. Craig. "How Landfills Work." *HowStuffWorks*. HowStuffWorks.com, 16 Oct. 2000. Web. 18 Dec. 2015. <http://science.howstuffworks.com/environmental/green-science/landfill6.htm>.

"Global Green Cities." *Global Green Cities*. N.p., n.d. Web. 18 Nov. 2015.

Grossman, Lev. "A Star Is Born." *Time* 2 Nov. 2015: 31-39. Print.

Kukreja, Rinkesh. "Waste To Energy - How to Produce Energy From Garbage and Waste - Conserve Energy Future." *ConserveEnergyFuture*. Conserve Energy Future, 22 Apr. 2013. Web. 16 Aug. 2015.

Kukreja, Rinkesh. "What Is Waste Management and Methods of Waste Disposal? - Conserve Energy Future." *ConserveEnergyFuture*. Conserve Energy Future, 23 Apr. 2014. Web. 16 Sept. 2015.

"Landfill Problems." *Landfill Problems*. We Green USA, n.d. Web. 18 Oct. 2015. <http://www.wegreen-usa.org/landfill-problems.html>.

NIEHS Office of Communications and Public Liasion. "Reduce Waste." - *Kids Pages*. National Institute of Environmental Health Sciences, 26 Nov. 2014. Web. 18 Oct. 2015. <http://kids.niehs.nih.gov/explore/reduce/reduce_waste.htm>.

Omenetto, Fiorenzo. "Silk, the Ancient Material of the Future." *Fiorenzo Omenetto:*. Ted Talks, May 2011. Web. 18 Oct. 2015. <http://www.ted.com/talks/fiorenzo_omenetto_silk_the_ancient_material_of_the_future>.

Royte, Elizabeth. "Corn Plastic to the Rescue." *Smithsonian*. Smithsonian, Aug. 2006. Web. 18 Sept. 2015. <http://www.smithsonianmag.com/science-nature/corn-plastic-to-the-rescue-126404720/?no-is&no-ist>.

Thorpe, David. "20 City and Regional Governments Pledge to Save 5% of Global Carbon Emissions." Web log post. *Sustainablecitiescollective*. N.p., 2 July 2015. Web. 26 Sept. 2015. <http://www.sustainablecitiescollective.com/david-thorpe/1086383/20-city-and-regional-governments-pledge-save-5-global-carbon-emissions>.

What Is Anaerobic Digestion. Prod. ShanksPLC's Channel. *Youtube*. ShanksPLC, 8 Oct. 2010. Web. 18 Sept. 2015. <https://youtu.be/5dErUHBjR0o>.

Wolman, David. "High-Powered Plasma Turns Garbage Into Gas." *Wired.com*. Conde Nast Digital, 20 Jan. 2012. Web. 16 Sept. 2015.

Woodford, Chris. "Bioplastics and Biodegradable Plastics." - *How Do They Work?* Bioplastics, 2 July 2015. Web. 18 Sept. 2015. <http://www.explainthatstuff.com/bioplastics.html>.

Zimmer, Lori. "TREEPODS: Carbon-Scrubbing Artificial Trees for Boston City Streets." Web log post. *Inhabitat.com*. Inhabitat, 15 Feb. 2011. Web. 15 Oct. 2015. <http://inhabitat.com/treepods-carbon-scrubbing-artificial-trees-for-boston-city-streets/>.