



Zoocycle FAQs

PROJECT MOTIVATION

1. *Why does the zoo want to do this?* Denver Zoo's mission is to secure a better world for animals through human understanding. This is an exciting project that supports our overall mission and specifically our sustainability goals (EDOP) by eliminating 1.5 million pounds of trash from entering landfill, while fulfilling 20 percent of our energy needs. The design intent is to holistically improve our procurement, operational, waste and energy footprints. Being sustainable includes responsible consideration of multiple inputs from sourcing to waste reduction and production of energy.

RECYCLING

2. *Will the zoo continue to recycle?* One of the additional benefits of our system is the natural fit with recycling. We will continue to recycle and compost waste from the zoo and the system.

INCINERATION VS. GASIFICATION

3. *Gasification sounds like burning. How is that environmentally friendly?*
Gasification is not burning or combustion (Arena and Mastellone, 2009). We create a low oxygen environment to prevent combustion and break down biomass by exposing it high temperatures (Al-Salem, 2010; Arena and Mastellone, 2009). The process will convert our fuel pellets (created from pre-sorted zoo trash and selected animal wastes) to create a combustible gas which will be used to run a generator to create electricity (EDOP; Arena and Mastellone, 2009). It is important to note the distinction that gasification produces a combustible gas, while combustion of waste (i.e. incineration) consumes the combustible gas (Arafat and Jijakli, 2013; Higman and van der Burgt, 2008). In comparing this technology with combustion of waste (i.e. incineration) the process is considered more environmentally friendly because it produces less carbon dioxide than combustion incineration (Arena, 2012; Huang, 2007; Marculescu, 2013).
4. *What is the maximum temperature needed to convert the fuel pellets to gas/electricity?* Actually, it may be better stated as the minimum temperature for gasification, which is approximately 600 - 800 degrees Celsius. (Arena and Mastellone, 2009)
5. *Why is this different than incineration?* This system does not include an incinerator, and instead it has a micro scale downdraft gasifier and an electrical generator (EDOP, Construction Air Permit). Gasification produces a combustible fuel (Ionescu, et al, 2010; Baggio et al, 2009). The main distinction includes a significantly different chemical reaction that includes gasification using 10 times less oxygen than combustion resulting in lower emissions and green-house gases (Arena, 2012; Huang, 2007; Marculescu, 2013).
6. *What other options did the zoo consider besides gasification?* A considerable commitment was made to identify a renewable energy technology that aligned with our sustainability targets. Investigations into current research on available technologies and life cycle assessments (US EPA-5) were considered. A technology was needed to integrate into our goals of recycling while promoting reuse and energy recovery. A technology that significantly reduced contributions to landfill and maintained the organization as responsible environmental stewards. The goal was to promote a sustainable culture that would foster a heightened awareness toward more sustainable practices from the organization, its guests and the community. Gasification showed considerable promise to fulfill all of these goals.

Using this technology in conjunction with our procurement practices and on-site segregation provides extensive control over our fuel stream to maximize the gasification system performance and emissions. The generation of heat energy and syngas will provide a valuable resource of recovered energy to significantly lessen our demand on



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traditional fossil fuels. In addition to eliminating a considerable portion of our waste to landfills, we will further lower our carbon footprint through reduced transportation.

SAFETY

7. *Has the zoo performed a “risk assessment” on this system?* As part of the Engineering Design and Operation Plan (EDOP, section 11.2.3N), Denver Zoo outlines strategies for managing site safety controls. Currently under the direction of the Denver Fire Department and Denver Zoo’s licensed engineering consultants, we are compiling a report on the evaluation of combustible dust and proposed control measures. This report will address the Safety/Material Assessment (Appendix J) of the EDOP. Per the EDOP, this report related to material handling will be shared with City and County of Denver-Department of Environmental Health and CDPHE. In addition, Denver Zoo maintains a third party certified safety management program that establishes guidelines for the performance of site hazard assessments (OHSAS 18001) for changes or new operations. In accordance with our own internal policies and programs, we are completing the assessments associated with the waste to fuel portion of the system.

ENERGY AND EFFICIENCY

8. *Please explain the fuel to electricity portion of the system.* The process from fuel to electricity is a two-stage process. The first includes the process of gasification to convert solid waste into syngas (Arena and Mastellone, 2009). The second produces electricity from what is a typical combustion generator. The engine turns the generator with mechanical energy to produce electrical energy, or electricity. What becomes most important is that gasification produces a combustible fuel (Ionescu, et al, 2010; Baggio et al, 2009), where our generator, or other types of combustion motors, consume the gas to produce electrical energy. Once the generator has consumed the fuel, the syngas is oxygenated and can no longer be combusted again. Arguments have been made to demonstrate gasification can be more efficient than incineration of MSW when compared in equal scales (Genon and Durante, 2010).
9. *Sierra Club and PSR contend modern power plants (coal and natural gas) produce electricity with less air emissions per unit. Is that charge correct?* This is an apples to oranges comparison. Our small, distributed energy system benefits from the renewable resources that make up a majority of our fuel and the very important diversion or conversion of our waste. Coal and natural gas plants are exponentially larger than the zoo’s system, in the range of 4,000 times larger. The Zoo’s small system will divert an estimated 1.5 million pounds from landfill annually, while fulfilling 20 percent of our energy needs and meeting the stringent air quality standards set by the state. It’s worth noting, public recognition of waste to energy (WTE) as a power source “with less environmental impact than almost any other source of electricity” is on the rise (US EPA, 2003; Rechberger and Schöller, 2006). Arguments have been made to demonstrate gasification can be more efficient than incineration of MSW when compared in equal scales (Genon and Durante, 2010).

OTHER

10. *Why is the zoo claiming Confidential Business Information (CBI)?*
Measurable time and energy was invested into the research and development of a process that aligned with the organization’s goals and needs to promote sustainable practices. As a consequence of its efforts, novel methods were established that led to the submission of patent applications to capture and document the unique processes developed at Denver Zoo. The organization identified very minor segments of the permit that may have revealed intellectual property components not currently protected within the patent. The organization continues to maintain transparency into all aspects of its operation, while protecting its investments into the process methodology.



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11. *What are the by-products of gasification?* By-products from this system will include generation of syngas and ash (Arena and Mastellone, 2009). Both of these by-products are heavily regulated by State and Federal regulations. The system will only operate while meeting the stringent emission standards as outlined in the permits (Construction Air Permit), set by US EPA and State regulators. Controlled air emission points will be constantly monitored, verified, and reported to Colorado Department of Public Health and Environment (CDPHE). Ash is a by-product which may have reuse for composting and other applications (Al-Salem, 2010; Scheirs, 1998; Vermeulen, 2011; Arena, 2006) although further testing is needed once the system is operational.
12. *What is Syngas?* –Syngas, or synthesis gas, is a fuel/gas mixture consisting primarily of hydrogen (Wallmann, 1998), carbon monoxide, and very often some carbon dioxide. Syngas is the combustible gas resulting from the gasification process, and is the fuel used to produce electrical or thermal energy.
13. *What do you mean by zoo trash?* What types of waste will make up the fuel? woodchips, all animal waste, cardboard, food waste, yard trimmings, alfalfa, hay, waste paper, paperboard, PLA plastic, PET plastic, HDPE/LDPE plastic.
14. *When you are referring to waste, waste stream or trash, are you referring to municipal solid waste (MSW)?* This is not municipal solid waste (MSW). Our waste does not fully encompass the commonly considered items in MSW, such as furniture, metals, glass, appliances, paints, batteries, tires, light bulbs, rubber, chemicals, etc. (US EPA-4). In fact Denver Zoo's fuel will be comprised of 90-92% organics (woodchips, all animal waste, cardboard, food waste, yard trimmings, alfalfa, hay, waste paper, paperboard) and 8-10% (PLA plastic, PET plastic, HDPE/LDPE plastic). Our fuel **will not** contain metals, glass, certain plastics (including chlorinated plastics), construction debris, electronics, furniture, paints, batteries, tires, light bulbs, chemicals, etc. Our fuel will only be comprised of materials generated at Denver Zoo and will not include materials from outside sources.
15. *How many tons of waste per day or week to be converted?* Estimated 4 tons/day of zoo waste only (EDOP). Our air permit limits the fuel stream to be only from the zoo campus (Construction Air Permit).
16. *How will the zoo ensure only acceptable waste streams enter the system?* The zoo has developed a very sophisticated operational system for procurement, sorting and collection so that we have full control of what is accepted into the fuel stream. This control aspect leads to a better composition of fuel and the composition of the by-products (emissions and ash) from the system.
17. *How many tons of various compounds will be released?* Denver Zoo was issued a Construction Air Permit by CDPHE. This permit sets the maximum limits (tons/year) that our system is permitted to emit for various compounds (Construction Permit). The system can only operate within these limits. This permit also sets requirements for Denver Zoo to perform initial source testing on each of the permitted emission points, which will demonstrate our compliance and actual emissions. These tests are performed by a State certified third-party.
18. *How will Denver Zoo control emissions from the system?* All of the emission points of the system are controlled to meet our permit requirements (Construction Air Permit). Our control measures include capturing particulate matter, gas monitoring devices, continuous emissions monitoring systems, gas clean-up (scrubber), thermal oxidizer (Construction Air Permit). In addition, our efforts associated with procurement, pre-sorting and collection will further support control of the fuel stream, which will result in cleaner emissions.



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19. *What equipment are you moving into the facility?* We are in the process completing construction of the waste to fuel development components of the system in our 3,000 square foot Waste Management Building located at Denver Zoo (EDOP).
20. *When do zoo officials anticipate it will start?* We should be converting our zoo waste into fuel pellets within the next eight months.

NUISANCE (smoke, odor, noise)

21. *Will there be smoke?* – No. Denver Zoo is committed to ensuring the system does not interfere with the experience of our guest or the comfort of our animals and neighbors in City Park. The system may produce some steam on cool days. Denver Zoo is required to monitor opacity as outlined in our air permit, regulated by the State.
22. *Will there be an odor?* – We do not anticipate odors beyond our current levels. As an environmental steward and good neighbor, Denver Zoo is committed to ensuring the system meets the highest environmental and safety standards and does not negatively affect our staff, guests, park users, or the animals under our care. Through this system waste will be processed on-site, and eliminated every three days instead of the current weekly hauling of solid waste through City Park. Therefore waste management odor is not expected to be an issue, although we have developed a response protocol if such an issue arises (EDOP). Waste management for the system will be performed in the same location it is currently occurring and has occurred for the past several decades.
23. *Will it be noisy?* – No. Denver Zoo is committed to ensuring the system does not interfere with the experience of our guest or the comfort of our animals and neighbors in City Park. This system is contained within a building to eliminate potential noise pollution and it is not anticipated to be noisy for visitors of the Zoo or City Park. We have developed a response protocol a noise issue arises (EDOP).



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