Improving the Efficiency of Remotely Located Composting Toilets

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MISSION STATEMENT

Solar Waste Solutions seeks to provide an engineering solution to the current waste management challenges found in the backcountry of America and in developing nations worldwide. As we strive to promote public health and protect environmental integrity, we will incorporate solar technology to design a system that will transform waste into an inert, dehydrated, light, and safe substance to handle and dispose of. This system will require infrequent maintenance and improve the management of waste in remote areas year round.

PROJECT BACKGROUND

- Project Sponsor: National Park Service
- Remote sites such as the backcountry of Yosemite National Park rely on composting toilets for waste management.
- These remote sites can experience low temperatures that inhibit/halt the composting process because the bacteria needed to breakdown the waste are not performing at their optimum temperature of 15°C.
- The remote location of the composting toilets makes it difficult to remove waste out of the backcountry.

PROBLEM STATEMENT

- **Design an off-grid, reliable, and inexpensive solution to existing, commercially available composting toilets.**
  - Current composting toilets in Yosemite require the waste to be transported out of remote areas via mule or helicopter.
  - Liquid slurry is a hazardous material, creating environmental risk during transportation.
  - Water adds weight, requiring additional trips to remove waste.
  - Low temperatures halt or impede current composting systems.

CONSTRAINTS & REQUIREMENTS

Constraints

- Federal Wilderness Regulations, Safety, Temperature, Sound, Materials, Fire, Watershed Protection
- Federal Wilderness “minimalist” regulations
- Mitigate fire hazards (special concern)

Requirements

- Withstand snow, rain, sun (UV), lightning
- Must withstand ambient temperatures from -24°C to 37°C
- Must operate in high winds, >80KPH
- Must use inexpensive, easily assembled pieces
- Minimize heat released to the environment
- Prevent corrosion from wildlife interaction

PROPOSED SOLUTION

- External Compound Parabolic Concentrator (XCPC) heats oil flowing through; oil then heats oven
- Oven reaches temperatures over 100°C, evaporating excess moisture and killing pathogens
- End product is inert, dehydrated, light-weight, and safe

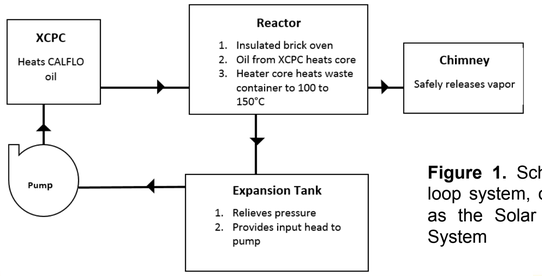

Figure 1. Schematic of open loop system, otherwise known as the Solar Waste Solution System

DESIGN: Solar Waste Solution System

Figure 2. Picture of Solar Waste Solution System at UC Merced Castle Facility

COST ANALYSIS

COMPONENTS	COSTS
Pump	$202.25
Plumbing	$572.75
Expansion Tank	$290.92
Shelf	$95.30
XCPC	$3.56
Waste Container	$130.82
Oven	$106.73
Chimney	$57.43
Miscellaneos	$103.14
Subtotal	*$1,562.90*
Taxes	*$117.44*
S & H	*$5.99*
Shipping Only	*$118.18*
TOTAL	**$1,804.51**

SWOT ANALYSIS

Strength	Weakness
•Solar powered •Low electricity requirements •Performs under extreme conditions •Operates with little power (100 W) •Low maintenance-suitable for backcountry •Materials can be easily obtained anywhere	•Insulation issues •Immobile •Inefficient operating temperature (XCPC is for 150 °C to 200 °C)
Opportunity	**Threats**
•Establishing connections with Yosemite, Mongolian Affiliates, & Nepal Affiliates •Good public relations for those involved •There are no competitors	•Environmental regulations differ from country to country •Difficulty integrating into commercial systems

PHYSICAL TESTING & SUMMARY

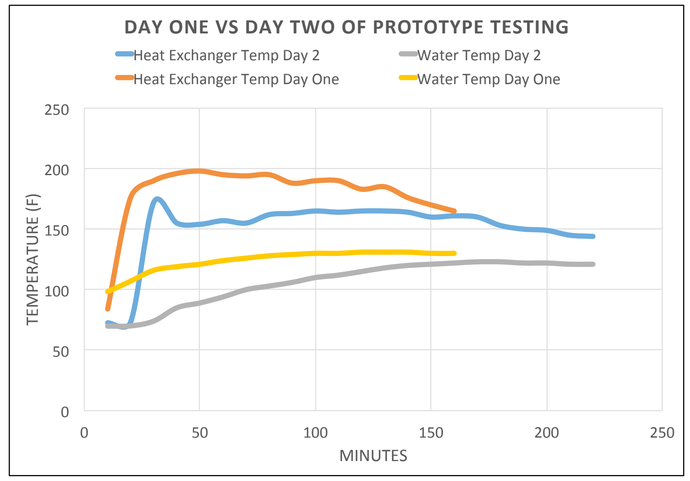

Table 1. Plot describing the temperature trends (max and min) of the water heated inside the waste container inside the brick oven for two separate days. Plot also demonstrates the temperature trends (max and min) of the heating core for two separate days. It can be seen that the water reached a maximum temperature of 123°F on day 2 and on day 1 the water reached a maximum temperature of 131°F. From the preliminary results it can be concluded that our oven is not reaching the minimum temperature desired of 212°F (100°C) to boil off water. Future capstone teams will have to improve the heating component of the system.

DELIVERABLES

- Working prototype, able to boil off 2 liters of distilled water on a sunny day
- Build solid foundation for future capstone groups to expand on prototype
  - Maintain detailed parts list (links, dimensions, price)
  - Create instructions for operation
  - List of the thermodynamic properties of the system

FUTURE CAPSTONES

- Filter noxious gases caused by heating human waste
- Incorporate heating element into existing infrastructure that is currently in Yosemite
- Automate operation and data collection
- Develop better bulking agent to increase composting efficiency, which will decrease initial water content
- Develop a masking technology to eliminate the glare from the XCPC

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