“Sustainable Eco-Friendly Compost Waste Heat Powerplant Design and Analysis”

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This poster demonstrates the design and analysis of a fully sustainable Rankine cycle powerplant operating on compost waste heat with the possibility of supplemental solar thermal energy. The powerplant demonstrated in this poster utilizes the waste heat generated by the decay of green matter in a compost pile to produce reliable and sustainable energy. The main source of energy for this plant is to be the compost waste heat, thus allowing the facility to operate 24/7 as opposed to wind farms and solar farms, which can only operate during certain hours of the day. The proposed plant does, however, have the capability to make use of solar energy during the day by means of a supplementary concentrating solar power (CSP) facility. The analysis presented in this poster estimates that 110,000 kWh/year (enough electricity to power 10 homes) can be derived from a seven acre-foot compost pile with supplementary CSP energy; such a facility is predicted to require one acre. This concept can be scaled readily to achieve higher energy production capacities, but this analysis concentrated on a 10-home baseline. This poster presents the design studies conducted to determine the ideal Rankine cycles for this plant when operating in daylight with CSP energy and at night with only compost energy. These ideal Rankine cycles were determined using a MATLAB Rankine cycle solver implementation of CoolProp, which is a fluid property database. This poster also presents the fluids analyzed and the fluid selection methods for this proposal. Several fluids were studied for this powerplant including isobutane, propane, isopentane, R245fa, and ammonia. In the end, isobutane was the selected fluid for this plant due to its beneficial properties. The Rankine cycle design and associated trade studies, conducted using the MATLAB implementation discussed previously, are also presented in this poster. Trade studies were conducted to determine the optimal feedwater heater setup and the best superheat state provided by the CSP array. The final cycles proposed have thermal efficiencies of 5.4% and 6.9% for the day and night cycles respectively; these efficiencies are low due to the very low-grade waste heat that is derived from compost. The maximum temperature for healthy compost is 140 °F and, when accounting for heat exchanger losses, the maximum cycle temperature falls to around 120 °F. The use of low-grade waste heat is directly responsible for the poor thermal efficiencies of the proposed cycles. The net work output from the day and night cycles was found to be 17.128 Btu/lbm and 9.057 Btu/lbm respectively. The trade studies suggested that the optimal feedwater heater arrangement would consist of 3 closed feedwater heaters with drains cascading backwards and a single, low pressure, open feedwater heater. This arrangement was found to yield the highest efficiency gain for the lowest increase in cost. All of these studies and findings were discussed in detail in the current poster. The poster also presents the design and analysis of the main heat exchanger for the plant. This heat exchanger is responsible for transferring energy from the low-grade compost heat to the isobutane working fluid. The design of this heat exchanger was challenging for several reasons including the low temperature of the waste heat and the high levels of latent heat entrained within the

moisture present in the air extracted from the compost pile. The heat exchanger design and analysis was conducted using Simscape, which is a one dimensional physical simulation software built into the MATLAB/Simulink environment. This poster presents the Simscape model developed for the purpose of designing the compost waste heat to isobutane heat exchanger. Further analyses presented in the poster discuss the assessment of the compost waste heat energy potential, which was then used to estimate how much energy could be derived from the pile. This poster presents the full scope of work in the design and analysis of the compost waste heat to power concept which seeks to provide a reliable means of energy derived from the composting process.