Undergraduate Thesis Prospectus

Conversion of Municipal Solid Waste to Energy

(technical research project in Chemical Engineering)

Resistance to the Dakota Access Pipeline

(STS research project)

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem

How is U.S. environmental sustainability being restrained?

The *why* in switching from fossil fuels to renewable sources has long been obvious, but the *how* is controversial. Fossil fuels are a substantial source of greenhouse gas emissions. The main contributors of greenhouse gas emissions in the U.S. are transportation and electrical power, respectively, at over a quarter each. Of these, more than 90 percent of transportation emissions are from petroleum and almost two-thirds for electricity are from natural gas and coal (EPA, 2019). Acid rain, mercuric emissions and bioaccumulation, and oil spills are further dangers owing to nonrenewable energy. Nonrenewable energy threatens the health and security of biodiversity and will inevitably collapse, yet these sources are still dominant (Greentumble, 2017).

The obstacles to renewable energy are, in part, social. Renewable energy often requires prohibitive initial investments whereas nonrenewable sources are readily available and cheap. Renewables typically require subsidies to be competitive. Fossil fuel companies exert substantial political influence. A rapid shift to renewables would render extensive infrastructure, such as pipeline networks, obsolete. The shift to renewable resources therefore demands complex planning (Greentumble, 2017).

Transforming Municipal Waste into Energy

How can the incidence of landfill waste and plastic be reduced?

The technical project will investigate a method for reducing municipal solid waste (MSW). The United States lacks efficient techniques of waste separation and relies on single-stream recycling processes, processes in which all recyclables are combined into a single

receptacle. Of the 633 recycling facilities in the country, less than 10% of recycled materials enter the recycling stream, 15% of recycled materials are burned in waste-to-energy facilities, and the remainder end up in landfills where they accumulate and eventually find their way into the environment, thus contributing to pollution (O'Neill, 2018).

To address this problem, this project will repurpose MSW for the production of hydrocarbon fuels and other energy-abundant materials. The primary end-goal of the design is to reduce the quantity of solid waste that goes to landfills, coupled with carbon capture. A potential secondary effect is the affordable energy-source material, since the components in the feedstock used in the design's energy production, such as plastics, may be obtained for a profit (Al-Salem SM, 2019).

One approach to the waste-to-energy system is pyrolysis, a process that includes a thermochemical conversion of carbonaceous substances to fuel (Eilhann et al., 2019). Rather than producing significant CO_2 emissions, this process utilizes CO_2 to suppress harmful chemical formation (Eilhann et al., 2019). Alternatively, Niu et al. (2013) claim gasification as superior since it increases hydrogen yield by 500% compared to pyrolysis.

The first step of the proposed process will involve gasification; the process of converting carbon-containing materials in the presence of heat, such as plastics in MSW, into a gaseous product called synthesis gas. This *syngas* is a mixture of carbon monoxide, methane, hydrogen gas, carbon dioxide gas, and heavier hydrocarbons). The syngas will undergo a water-gas shift reaction to produce fuel that will be fed to a solid oxide fuel cell (SOFC) combined with a gas turbine and organic Rankine cycle to generate electricity. The combined cycle is superior to the standalone SOFC due to the heat waste capture: The Organic Rankine Cycle captures residual heat from the gas turbine, which captures heat from the fuel cell. The three units in series makes

the process 8-12% more efficient than the standalone fuel cell, implying less fuel consumption and pollutant emissions. (Ragini et al., 2018). Carbon dioxide gas produced from gasification will be trapped via carbon-capturing, thus making the overall process more sustainable. The carbon dioxide recovered will be stored and sold. Ash formed in the gasification chamber will be collected and treated for disposal or converted to commercial material (Ardolino et al., 2018). The process is summarized in Figure 1.

Project personnel are Elias Azar, Kevin Bahati, Ally Hermans, and Naseem Hussein, fourth-year students in the Chemical Engineering department at the University of Virginia. The technical project will be developed in the courses of Process, Synthesis, Modeling & Control, and Chemical Engineering Design over two semesters, directed by Professor Eric Anderson in the Chemical Engineering department at the University of Virginia. The project will require the use of Aspen Plus simulation software, a computer program used by chemical engineers to design chemical processes. Economic analysis and research methods to recover and efficiently reprocess MSW will also be provided, as well as the implementation of a safe plant environment

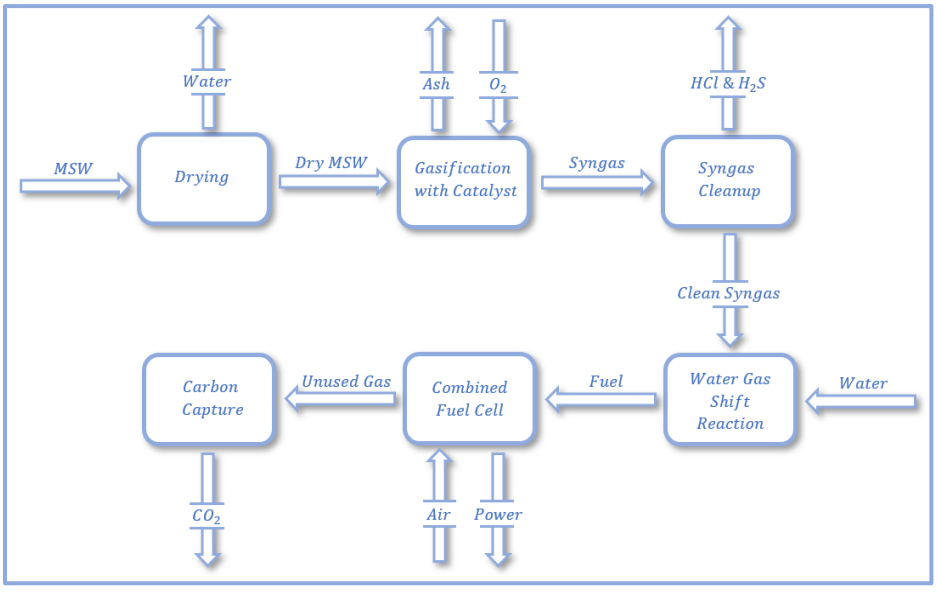

Figure 1: Municipal Waste Recovery to Energy Scheme: The figure describes the process of municipal waste recovery to energy including a gasifier, water gas shift reaction, combined fuel cell, and carbon capture. (Bahati, 2019).

for production of energy. By the end of March 2020, the project design report will be delivered with an estimation of the process, cost, and profit.

Skeptical Motives: Dakota Access Pipeline

How is resistance to the Dakota Access Pipeline explained?

On March 10, 2018, officers in Washington, D.C., coordinated traffic as protestors meandered towards the White House. *Mni Waconi* ("water is life") was their motto as they protested the Dakota Access Pipeline's infringement of Native Americans' territorial rights.

The Dakota Access Pipeline is a controversial investment in an unsustainable industry. Assuming constant consumption of crude oil at present rates, projections based on British Petroleum data indicate crude oil depletion in fifty years (Ritchie, 2017). The pipeline currently moves 40 percent of Bakken oil production at over half a million barrels daily. Energy Transfer Partners, the pipeline's builder, defends the pipeline as a "safer means of transportation over truck and rail" and as a source of jobs and internal revenue (ETP, n.d.). Pipelines are far less likely to incur spills, yet risk contamination of groundwater and farmland. Honor the Earth contends that photovoltaic systems, wind towers, and retrofit packages would have been wiser investments (HtE, n.d.).

The Dakota Access Pipeline exacerbates longstanding distrust among indigenous peoples of the U.S. government. According to Whyte (2017), the permits for construction on the "environmentally and culturally significant" indigenous grounds were "never ceded consensually." He claims that the project continues a history seeking to "erase Indigenous peoples culturally, economically, and politically" through U.S. settler colonialism.

The controversy is also indicative of political strife and corporate ambition facilitated by government agency. By executive order, President Trump thwarted an Army Corps of Engineers' environmental study before construction at Standing Rock. In response, Greenpeace attacked the Trump administration, alleging a conflict of interest. Trump's financial disclosure form revealed investments in corporate beneficiaries of the project. The president's energy advisor, Harold Hamm, is CEO of an oil company that seeks to use the pipelines: Continental Resources (Greenpeace, n.d.). The pipeline's right of way is secured through eminent domain, upheld in *City of Little Rock v. Raines*, which critics fault for violating the "public use" standard. *Linder* and *Smith v. Arkansas Midstream Gas Services Corp.* (Means, 2011) established similar precedents, by which private projects that serve purportedly public purposes may condemn property (Justia, n.d.).

Pipelines can interrupt drainage patterns, compact and disrupt soil composition, and compromise future agriculture (Streuber, 2018). Farmer Steve Hickenbottom confirms: "you cannot move 30 feet of dirt and put it back like it was" (Streuber, 2018). Easements do not account for losses, complicating the fair compensation principle. Breuninger and Thompson (1979) demonstrated that mixture of soil horizons alters "porosity, permeability, infiltration rates," and acidity. Residual oils in trace amounts create alkaline conditions, risk fire, and seep into seed embryos, inhibiting germination (Breuninger & Thompson, 1979).

The North Dakota Petroleum Council backs the pipeline. Council members "promote and enhance the … marketing of oil and gas in North Dakota" through lobbying and handling regulatory and legal complications (NDPC, n.d.). NDPC is a trade association representing Energy Transfer Partners and other companies interested in the Access Pipeline.

Opponents to the pipeline include Honor the Earth, whose “mission is to create awareness and support for Native environmental issues,” and provide “financial and political resources” for indigenous sustainability through public awareness, media, and music (HtE, n.d.). The organization supports pipeline opponents on the “frontlines,” directing “action teams, and … legal teams” (HtE, n.d.).

Environmental organizations are also engaged, including Greenpeace and the Sierra Club’s Iowa Chapter. Responsibility for exposing executive investments in the pipeline owes to Greenpeace exposed investors in the pipeline. Its mission is to “expose global environmental problems and promote solutions … essential to a green and peaceful future” (Greenpeace, n.d.). Sierra Club operates with “state agencies, the Iowa Legislature, and other environmental organizations to protect Iowa’s environment” through legal action. The chapter has challenged the pipeline’s claim to public benefit and eminent domain rights in Iowa’s Supreme Court (Sierra Club: Iowa Chapter, n.d.). Bold Iowa defends landowners’ rights against proponents of the pipeline and claims to fight “extreme ideas and policies that protect big business and special interests” (Bold Iowa, n.d.).

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