

Undergraduate Thesis Prospectus

Resourcefully Recovering Municipal Solid Waste

(technical research project in Chemical Engineering)

Climate Change Denial in the United States

(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 can we improve sustainability globally?

In a sustainability economy, one generation meets its needs without compromising future generations capacity to meet theirs. Global challenges include those related to poverty, inequality, climate, peace and justice, environmental degradation, and prosperity (UN, n.d.).

Resourcefully Recovering Municipal Waste

How can we reduce plastic waste?

Project personnel include 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 course of the two-semester capstone class directed by Eric Anderson. This technical project will investigate a method for reduction of plastic waste currently contaminating landfills. The United States lacks efficient separation of waste materials and relies on single-stream recycling processes in which all of the recyclables are placed in the same receptacles. Of the 633 recycling facilities in the US, less than 10% of recycled materials enter the recycling stream, while 15% of recycled materials are burned in waste to energy facilities and the remaining 75% end up in landfills (O'Neill, 2018).

To address this problem, the project will repurpose municipal solid waste (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 price reduction of energy-source material, since the components in the feedstock used in the design's

energy production, such as plastics, may be obtained for less than their industrial price (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 CO₂ emissions, this process utilizes CO₂ 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 in the process will involve gasification (see *Figure 1* below for a block flow diagram of the entire process). Gasification is the process of converting carbon-containing materials in the presence of heat, such as plastics in MSW, into a gaseous product called synthesis gas, or “syngas.” Syngas is a mixture of carbon monoxide, methane, hydrogen gas, carbon dioxide gas, and heavier hydrocarbons. The syngas will be passed through 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 heat from the gas turbine, which captures heat from the fuel cell. The three units in series makes the process 8-12% more efficient, 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 a.l., 2018).

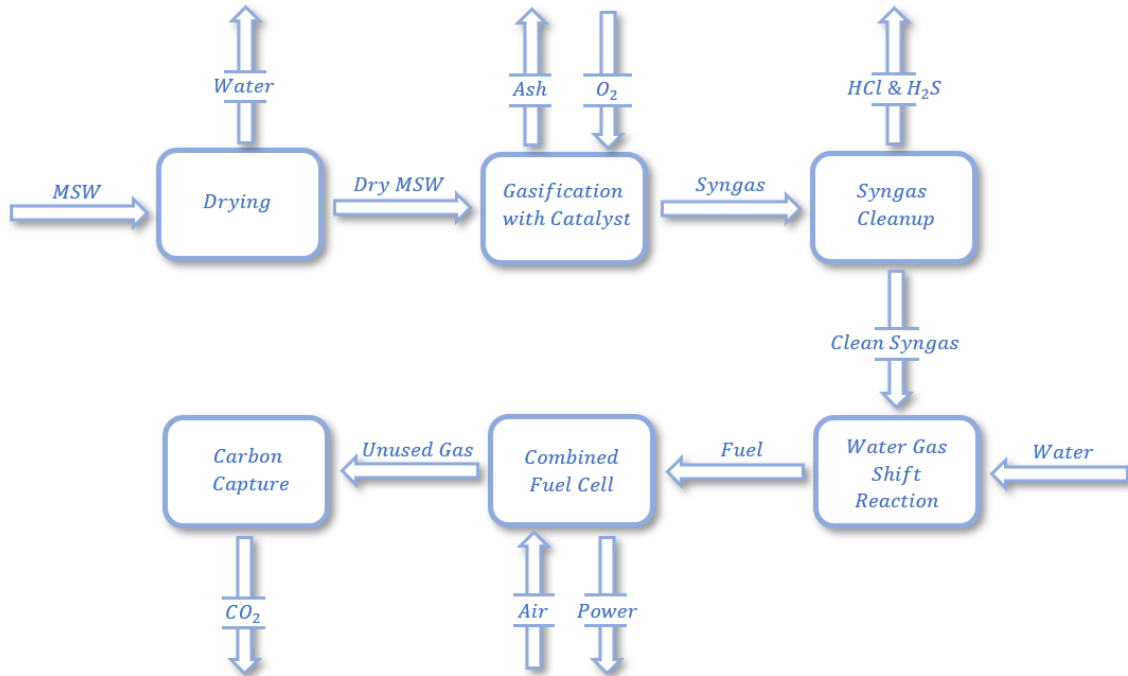


Figure 1: Municipal Waste Recovery to Energy Scheme: The figure describes the process of municipal waste recovery to energy including a gasifier, water gas shift reaction, combined fuel cell, and carbon capture. (Bahati, 2019)

The project will require the use of Aspen Simulation, 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 for the 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.

Table 1 shows the four phases of the project, spanning from early November 2019 through late March 2020. The tasks associated with the four phases are the Design Basis, Proposal, Progress Report, and the Final Report. The Design Basis (phase 1) includes a full report detailing the feedstock, basic process scheme, and the products. The Proposal (phase 2) will contain basic economic motivation and a design basis.

Progress Reports (phase 3) will be provided every three weeks to address progress before the completion of the Final Report at the end of March (phase 4).

Task Name	Q4			Q1		
	Oct	Nov	Dec	Jan	Feb	Mar
1 Design Basis		■				
2 Proposal				■		
3 Progress Report					■	
4 Final Report						■

Table 1: Project Timeline: The table gives a rough estimate of the time needed to complete the required work to design the project (Hussein, 2019).

Climate Change Denial in the United States

How can climate change denial be explained?

Recent climate change is due in part to human activity, generating emissions of heat-trapping greenhouse gases (GHGs) (Kalogirou, 2014). Burning of fossil fuels is a primary cause of GHG emissions. Think-tanks, some funded by fossil fuel industries, have promoted skepticism about humans' contributions to climate change. Such efforts can confuse the public and delay efforts to fight climate change.

Awareness of environmental problems grew when Rachel Carson's *Silent Spring* was published in 1962 (Carson, 1962); In 1970, during the Nixon administration, the Environmental Protection Agency (EPA) enforced new environmental standards (Nixon, 1970, para. 2). However, in 1981, President Reagan and Congress reduced environmental regulations (Dunlap & McCright, 2010). The Heritage Foundation joined the efforts to influence public opinion and policy. Reagan (1988) referred to the Heritage Foundation as being a "vital force" during his administration.

Marquart-Pyatt et al. (2019) found that in general, Democrats are more concerned about sustainability than Republicans. Relative to the Obama administration, the Trump administration is uninterested in carbon reduction and favors fossil fuels (Davenport & Lipton, 2016). As a presidential candidate, Trump selected fossil-fuel ally Scott Pruitt to head EPA (Davenport & Lipton, 2016). In 2017, under Pruitt's support, President Trump announced that the US will withdraw from the Paris Climate Agreement, an international step towards reducing GHG emissions (Bush, 2018). Pruitt resigned in July 2018 in response to controversies, and was replaced by former coal lobbyist Andrew White (Bush, 2018). In August 2018, Trump's EPA proposed an Affordable Clean Energy (ACE) Rule, protecting the coal industry while limiting emissions. Months later, Trump proposed revisions to allow coal plants to emit more CO₂ (EPA, 2018).

Think-tanks such as the Heritage Foundation, the Heartland Institute and the Cato Institute seek to influence public policy decisions through publicity. They have publicized arguments skeptical of anthropogenic climate change and are often represented by contrarian scientists (Dunlap & McCright, 2010). Lehr and Burnett (2019) of the Heartland Institute claim climate change is a "hoax" and argue that abandoning fossil fuels would end life as we know it. The opposition also includes Americans for Prosperity and the American Petroleum Institute. In 2018, the Market Choice Act was introduced as a bill in Congress, imposing a tax on all fossil fuel emissions and within the first month, American for Prosperity attacked the bill, asserting that its costs would outweigh the benefits (AFP, 2018). According to AFP (2018), a carbon tax is an ineffective tool that may increase pollution. Murphy, Michaels

and Knappenberger (2018) of the Cato Institute claim there is mounting evidence that human-induced CO₂ emissions cause little warming and that a carbon tax is a dubious policy instrument. However, in 2019, the Cato Institute quietly shut down an effort to raise uncertainty of climate change after climatologist Michaels left (Waldman, 2019).

The American Petroleum Institute is a trade association representing all oil and gas industries nationwide. Some oil and gas industries companies now admit climate change and are shifting from coal to natural gas sources, alleging the switch cuts CO₂. (API, 2019). According to Panno et al. (2019), support for Trump and climate change denial are not clearly linked. Jessani and Harris (2018) conclude that to climate change deniers, climate change is not a problem, is not the result of human activity, and cannot be corrected.

Dunlap and McCright (2010) find that on average, Americans are much less concerned than the residents of many other countries about climate change, delaying action. Climate change awareness is influenced by trade; fossil fuel industries, think tanks, contrarian scientists, politicians, and conservative organizations. According to Bruelle (2013), the organizations that make up the climate change countermovement in the US have an annual income of over \$900 million, most of it from conservative foundations.

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