CARBON-NEUTRAL PRODUCTION OF METHANOL VIA DIRECT AIR CARBON CAPTURE

INVESTIGATION OF SOCIAL BARRIERS TO CARBON CAPTURE VIA ACTOR NETWORK THEORY

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With the increase in global temperatures brought on by alarmingly high rates of carbon dioxide emissions, many argue that the world needs to transition to net-zero emissions with capabilities to create negative emissions as well to reach climate change goals from the Paris Climate Agreement. To address this, the technical project seeks to design a theoretical chemical plant to facilitate a carbon-neutral process to produce methanol using carbon dioxide removed from the ambient atmosphere via Direct Air Capture (DAC) technology and procured blue hydrogen. The objective of the technical research is to demonstrate the technological and financial potential of DAC technology by using the captured carbon as a feedstock for methanol synthesis and to create a carbon-neutral method for the production of methanol, a process that traditionally expels a significant amount of emissions into the atmosphere. The STS research is an investigation of the most influential actors which impact the development of carbon capture technology through the lens of the Actor Network Theory (ANT), developed by Law, Callon, and Latour. This research sought to uncover why a technology such as carbon capture has not been widely accepted by society, despite it having the potential to solve global warming from anthropogenic sources. The technical and STS research topics are tightly coupled as the technical research investigates a method to improve the economics of carbon capture technology, one of the largest societal barriers found in the STS research.

The technical project seeks to create a bridge between the carbon-neutrality goals determined by the Paris Climate Agreement and a generation of profit given today's fossil-fuel based energy industry. Typically, carbon dioxide is sequestered post-capture from DAC technologies, so converting the captured carbon into a sellable fuel is intended to improve the economic viability of this technology. The technical project focuses on the theoretical design of a process that will separate and purify 1.2 trillion kilograms per year of carbon dioxide from ambient air which will be used as a feedstock, as well as hydrogen, for the generation of 420 million kilograms per year of methanol. The design includes considerations of material balances, heat exchange, major and ancillary equipment design, economic viability, and safety, health, and environmental concerns. The design was based upon published theoretical, empirical, and heuristic information about DAC and methanol synthesis processes coupled with simulations from ASPEN, a process simulation software for chemical processes.

The overall process was designed in two stages: upstream DAC processes and downstream methanol synthesis processes. The DAC subunit consists of 5 major unit operations responsible for separating and purifying carbon dioxide to 99.8% which include an Air Contactor, Pellet Reactor, Calciner, Slaker, and a Compression System. The methanol synthesis subunit consists of 3 major units to react the captured carbon dioxide with hydrogen to produce methanol which include a Reverse Water Gas Shift Reactor, Methanol Synthesis Reactor, and a Distillation Tower. Considering the upfront capital cost, manufacturing cost, and revenue from selling methanol, this design was not recommended to be considered for operation at this time due to its lack of economic viability.

The STS research focuses on the analysis of carbon capture and the role society has on its lack of implementation. Carbon capture technology has the potential to solve many issues relating to the increase in carbon dioxide emissions, yet the technology is not employed on a large scale. The research revolves around the question of which actor is most responsible for preventing the widespread use of carbon capture and what motivates this. The Actor Network Theory was used to investigate the issue as the framework considers the interactions between human and non-human actors, indicating that practices of technology and society are inherently intertwined. Alongside ANT, case studies were used to understand the motivations of the relevant actors.

Although there are many actors which impact the success of carbon capture, government funding is by far the most influential. Other actors, such as politicians, the fossil fuel industry, and the public, affect the implementation of carbon capture through influencing whether or not the novel technology receives financial support from the government. This is illustrated through the case studies surrounding the shut down of Petra Nova, a government and privately funded carbon capture and sequestration project, and the rejection of carbon capture in Cancer Alley, a region afflicted by high cancer rates attributed to the high presence of industrial facilities in the area.

As the world seeks to solve global warming, mitigative technology such as carbon capture can be an extremely advantageous solution, if implemented properly. As illustrated in the technical and STS research, there are many technological and societal barriers preventing its widespread implementation, but the continuation of research on carbon capture is still essential to begin reversing the distressing effects of climate change.

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