Economic Analysis for In-Situ Resource Utilization on Mars in Support of the Generation of Rocket Fuel and Potable Water

(Technical Thesis)

A Discussion of the Socioeconomic and Political Obstructions to Water Purification Technologies in China

(STS Research Paper)

An Undergraduate Thesis

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In Fulfillment of the Requirements for the Degree
Bachelor of Science in Chemical Engineering

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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STS Prospectus

Sociotechnical Synthesis

For decades, engineers have looked to solve problems on Earth and in space. My work aims to improve technology utilization and efficiency both in space and on Earth. For the technical project, my team designed a process that would produce rocket fuel on Mars, inspired by the idea of a Martian "gas station" for long distance space exploration missions. For my STS project, I analyzed the obstacles that stand in the way of the adoption of innovative water purification technologies in China.

The technical thesis details an In-Situ Resource Utilization (ISRU) process that produces methane, oxygen, and potable water on Mars. This process uses components from the Martian atmosphere and water in the form of ice from the Martian regolith layer to produce these products. The ISRU process was designed to produce methane and oxygen for use as rocket fuel for a return trip back to Earth within one cycle on Mars. In order to use these components for a return trip, 7.2 tons of methane and 28.8 tons of oxygen would need to be produced. We designed a complete and detailed process that employed the use of reactors, separations equipment, heat exchangers, nuclear generators, and storage tanks. The longevity of this design was not looked into, but the lifetime of each unit was found to have a minimum of three cycles, only needing replacements for consumables such as catalysts. An economic analysis was performed to determine the cost effectiveness of our design. Shipping enough rocket fuel from Earth would cost about $720 million, whereas our design would cost $818 million. This analysis did not include the cost of shipping potable water though, and when this was factored into the cost analysis, our mission would save $225 million. Multiple other economic analyses were performed under different scenarios and assumptions, in which we found many favorable

situations. Further steps include improving the energy consumption of our design, since the nuclear generators that provided said energy were extremely heavy and expensive.

The STS thesis investigates the political and socioeconomic obstacles that stand in the way of the implementation of innovative water purification technologies in China. This analysis uses the Multi-Level Perspective (MLP) framework to investigate the political, social, and economic landscape, as well as the systems that propagate water quality and quantity issues in China. Data was collected from various sources, including the UN Department of Economic and Social Affairs Population Division, the United Nations World Water Development Report, and the Worldwide Governance Indicators project. After data was collected on the desired country, analysis was performed on water purification technologies to determine their feasibility in China.

Work like this cannot be done alone, and I would like to thank my professors and classmates at UVA and NVCC. I'd also like to thank my friends and family for their love and support throughout my journey, with a special thanks and dedication of this project to my mother, who deserves more than I can ever repay her for.