Thesis Project Portfolio

Design of an In-Situ Fuel, Oxygen, and Potable Water Supply System on Manned Mars Missions

(Technical Report)

Applying Multilevel Perspective Analysis to Energy Justice in India

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

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In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Table of Contents

Sociotechnical Synthesis

Engineers seek to improve humanity through novel solutions to problems. Some see opportunities through projects on Earth. Others see the opportunity in the vast reaches of space. My work analyzes approaches to improve and expand human potential on Earth and Mars. The technical thesis covers a means to produce rocket fuel and astronaut essentials from the Martian surface for a manned excursion. It consists of novel technologies to process resources available on Mars that, in conjunction, create an economically viable process. Then, the STS thesis delves into the expansion of electricity infrastructure in India. It applies justice frameworks to measure the qualitative effectiveness of familiar and novel implementations of electrical systems in attempts to expand energy access throughout the country.

The technical thesis details a process that produces hydrogen, oxygen, and potable water on the Martian surface through In-Situ Resource Utilization (ISRU). Using only the components of the Martian atmosphere and water from the Martian regolith, we will produce hydrogen and oxygen as fuel and oxidizer for a return rocket, and enough oxygen and potable water for ten astronauts living on Mars in 1.5 year cycles. For a process that lasts 18 years, or 12 cycles, this means the production of 3,600 kg of hydrogen, 28,600 kg of oxygen, and 11,200 kg water in each cycle. We were able to devise a complete, detailed process with all reactor, separations, heat integration, energy, and storage technologies designed. Some process elements' were designed based on research only from the last decade. We found the process to be economically viable, as the lifetime cost of the process is less than the cost of equal fuel shipment from Earth to Mars. Further steps to improve the process include further heat integration optimization, better use of waste streams, and a more mass-efficient design for the oxygen producing reactor.

The STS thesis involves an investigation of energy justice in the implementation of electricity infrastructure in India. India used grid expansions and solar energy infrastructure to

expand electricity access to poor and rural communities. The paper's framework combines Multi-Level Perspective (MLP) characteristics and energy justice principles to analyze the success and failures of India's works. These criteria include distributive justice – the equal distribution of benefits and burdens – and cosmopolitan justice – the betterment of humanity or standards of living – which correspond to landscape and regime changes regarding the technology. The criteria also include procedural justice – individuals' ability to interact with governing bodies or technologies directly –corresponding to niche changes at the local level. The work finds mixed success with each energy justice component. India achieved distributional justice better than cosmopolitan, and cosmopolitan better than procedural. The work also finds that India's successes stand out from other countries in similar conditions, but had similar failures as Western nations. These lessons would benefit other countries to implement their own energy systems in just manner.