TECHNOLOGY ASSESSMENT FOR PRODUCING PROPELLANT FROM LUNAR WATER. A.J. Paz, NASA Johnson Space Center, (aaron.paz-1@nasa.gov)

Introduction: The presence of water ice in permanently shadowed regions (PSRs) on the lunar surface may enable a sustained human presence on the Moon with minimal need for consumables. One of the most valuable uses of lunar water is to produce rocket propellant. A sustained human presence on the Moon will require frequent launches from the lunar surface, and each launch will require tons of propellant. However, many other volatiles are likely to be present in the areas where lunar water is stable[1.] Producing propellant from lunar water in-situ will require the separation and purification of water before it can be electrolyzed into oxygen and hydrogen gas. The Resource Exploration and Science of OUR Cosmic Environment (RESOURCE) project, funded by the Solar System Exploration Research Virtual Institute (SSERVI) program, includes a task to demonstrate the end-to-end process of water extraction, capture, purification and electrolysis to produce pure/dry oxygen gas sourced from an icy regolith mixture.

Water Purification: The requirements for water purity are driven by the type of water electrolyzer used. For example, the water electrolyzer currently used on the International Space Station is based on proton exchange membrane (PEM) technology. PEM-based electrolyzers require water to be ultrapure and deionized (>10 MegaOhm-cm) so that electrical conductivity is limited to the membranes themselves, where electrical current is used to convert H_2O into H_2 and O_2.. A practical first step toward purifying water that is sourced from a lunar PSR is to use freeze distillation to separate water from other volatiles[2.] A sub-micronic filter can also be used to ensure that a minimal amount of dust is present in any lunar water that is captured. The combination of freeze distillation and sub-micronic filtration will result in relatively pure water but would require a deionization step if being fed into a PEM electrolyzer.

Water Electrolysis: An alternative to PEM electrolysis is to use a Solid Oxide Electrolyzer (SOE). This technology operates at a much higher operating temperature (~800^{o}C) and has a limited pressure range but does not require water to be ultrapure and deionized. Another advantage of SOE technology is that it produces pure dry oxygen gas without the need of an additional drying step. PEM electrolyzers produce humid oxygen gas and the humidity must be removed prior to liquefaction.

Assessment: In order to compare PEM and SOE technologies side-by-side, they must be compared at a system level that includes water purification and gas drying steps. Engineers at the Johnson Space Center updated and utilized a detailed In-Situ Resource Utilization (ISRU) system model to compare and select the best option for the RESOURCE project which will conclude with a laboratory demonstration of the process of producing pure/dry oxygen from an icy regolith mixture in 2025.

References:

[1] Colaprete, A., et. al.(2010). Detection of water in the LCROSS ejecta plume. *science*, *330*(6003), 463-468. [2] Holquist, J., et.al. (2020, July). Analysis of a Cold Trap as a Purification Step for Lunar Water Processing. 2020 International Conference on Environmental Systems.