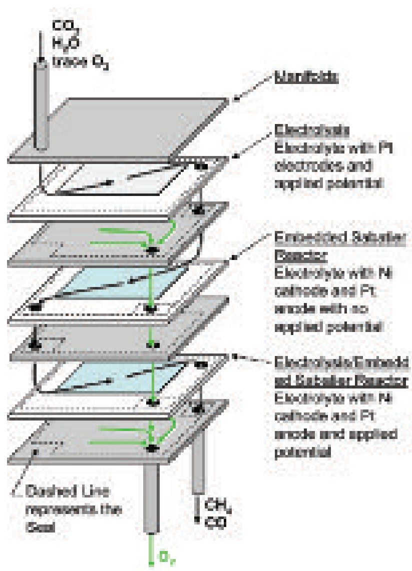
Solid Oxide Electrolysis

Paragon Space Development Corporation is developing Solid Oxide Electrolysis (SOE) as the next generation electrolysis/Sabatier subsystem to enable 100% oxygen regenerative air revitalization systems (ARS). Oxygen regenerated from a crew's expired CO_2 and H_2O vapor is essential to enabling a continuous human presence on the moon and distant exploration of Mars at significantly reduced cost and risks. Other applications include O_2 and propellant generation using lunar & Martian resources, O_2 regeneration for Navy and ocean research submersibles, and O_2 regeneration for hazardous material handlers, rescue personnel or other professionals performing in extreme environments.

This high temperature concept (up to 850°C) takes advantage of a SOE cell's inherent ability to regenerate O_2 from CO_2 and H_2O simultaneously, producing CO and H_2 as by-products. The by-product of CO and H_2 is addressed by employing Sabatier reactor technology embedded within the SOE unit to increase safety and reduce complexity/volume.

No other system can promise 100% oxygen regeneration without relying on consumables from Earth. Current water electrolysis/Sabatier reactor technology can only regenerate 80% of a human's oxygen requirement without the use of a consumable such as hydrogen. The SOE concept safely eliminates handling of hydrogen, and works irrespective of gravity and pressure environments with no moving parts and no multi-phase flows.



Example SOE Stack in Series with Embedded Sabatier Reactor (left). Assembly of SOE Pre-prototype (right)

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SOE testing in Paragon's Research and Development laboratory.

Under a NASA Small Business Innovative Research (SBIR) contract, Paragon is developing a to-scale pre-prototype. In support of this, Paragon developed 1-inch heaters in-house to attain up to 950°C temperatures in a small volume. Material testing was performed to identify manifolds that could withstand the high-temperature corrosive environments. A Sabatier catalyst was developed for this application and tested using gas chromatography to quantify methane production. Over one thousand hours of electrolysis testing has been performed using single cells to understand performance and influence the stack design. Chemical thermodynamic analyses were performed and corroborated with testing to show that the design will not incur carbon deposition in the unit. Manufacture and assembly of the pre-prototype is now complete and testing has begun.