# Advanced Materials for Energy and Cost-Efficient Large Scale Separations of Oxygen from Air

*Exceptional service in the national interest*

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

**Sandia National Laboratories is developing methods for the purification of oxygen from air for industrial uses, such as oxyfuel combustion. This technology can enable significant energy savings and reduced operation costs for industry, as well as reduced U.S. fossil fuel dependence.**

Sandia is focusing on Metal-Organic Framework-based separation technology, with improved adsorption capacity and competitive (or better) selectivity as compared to zeolites. These new materials are being integrated into newly developed oxyfuel combustion burner systems, guided by techno-economic analysis for optimized process performance. Industry-wide implementation will result in: (1) Extreme energy savings of about 50% per year, equaling 2.5 million MWh energy savings for U.S. industry, (2) Reduced capital and operating industry expenditures, and (3) Great reduction in the nation's fossil fuel dependence.

## Improved $O_2$ Separation

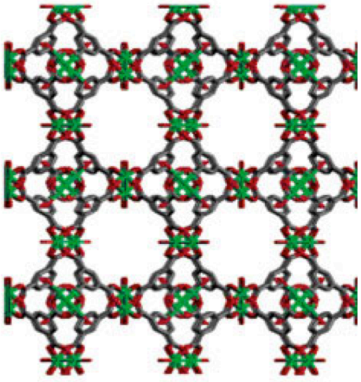
Cryogenic air separation, the most widely used technology for generating large flows of oxygen, generates $O_2$ with a purity of 90-99.5% and can scale to large production sizes. However, it is a complex and expensive technology, both in capital cost and energy consumption. Pressure swing adsorption (PSA) is a competing technology that takes advantage of differences in adsorption behavior to achieve separation or purification of one or more components of a gas mixture. PSA is currently constrained to applications that do not require $O_2$ purity greater than 94%. Existing PSA systems generally employ zeolites as the adsorbent material, and consist of a 6-step batch production process with significant capital cost. Improved $O_2$ separation materials for use at ambient pressure and temperature will translate into higher efficiency PSA processes, resulting in energy savings, reduced capital expenditure and a reduction in the national dependence on fossil fuel.

## The Future of $O_2$ Separation

The next steps will include scale-up of the Metal-Organic Frameworks (MOFs), techno-economic process planning and analysis of incorporating the separations into the PSA process and then integration with the burners. It will also be necessary to identify a path to manufacture the MOFs economically at a large scale based on commonly available raw materials. The cost of current zeolite-based PSA processes represents roughly equal contributions from capital and operating expenses, both of which will be significantly reduced with the use of highly selective MOFs that enable smaller adsorption bed volumes and less power for compression. Thus, cost savings will be realized even if MOFs are somewhat more costly to produce than zeolite adsorbents.

## Commercialization Path

We are pursuing multiple pathways to scale up, development and commercialization. Currently, we have two patents filed associated with this work: (1) MOF for oxygen separations from air, and (2) binder-free pelletization process for porous materials. We are interested in teaming with industry through licensing agreements, CRADAs or WFO to find manufacturers for the MOF materials and/or for the implementation of MOFs into Oxyfuel production processes.



*Use of MOFs for oxygen separation from air; one example: (top) Cu-BTC MOF framework, (bottom) homogenous Metal substitution into Cu-BTC MOF, M = Mn, Fe, Cu.*

**For more information visit:**
IP.sandia.gov

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2015-0504 M