the ENERGY lab

PROJECT FACTS

Gasification Technologies

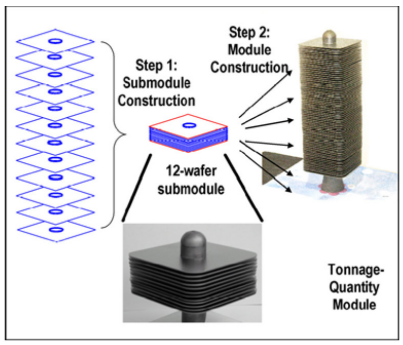
# Development of Ion Transport Membrane (ITM) Oxygen Technology for Integration in IGCC and Other Advanced Power Generation Systems

## Description

Air Products and Chemicals, Inc. is currently developing ion-transport membrane (ITM) oxygen separation technology for large-scale oxygen production and for integration with advanced power production facilities including gasification. The ITM Oxygen process uses non-porous, mixed ion and electron conducting materials operating typically at 800-900 °C. Ion and electron flow paths occur through the membrane counter-currently, and the driving force for oxygen separation is determined by the relative oxygen partial pressure gradient across the membrane, typically 200-300 pounds per square inch gauge (psig) on the air feed side and low to sub-atmospheric pressure on the oxygen permeate side. The energy of the hot, pressurized, non-permeate stream is typically recovered by a gas turbine power generation system. The development of ITMs will reduce the capital costs and parasitic load of air separation systems compared to the currently available cryogenic technology. Because air separation is a critical component of the gasification process for power production, any reductions in the cost of this component will in turn, reduce the overall costs of gasification, thereby making gasification more competitive.

## Primary Project Goals

The ITM Oxygen project aims to develop, scale up, and demonstrate a novel air separation technology for integration with integrated gasification combined cycle (IGCC) and other advanced power generation systems for large-scale power production. A three-phase technology research, development, and demonstration (RD&D) effort will demonstrate all necessary technical and economic requirements for further scale up and industrial commercialization. Phase I objectives, now completed, focused on materials and process research and development (R&D), and the design, construction, and operation of an approximately 0.1-ton-per-day (TPD) Technology Development Unit (TDU). The TDU test data allowed establishment of cost




*Commercial-Scale ITM Oxygen Modules*

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## PARTNERS

Air Products and Chemicals, Inc
Ceramatec, Inc.
Concepts NREC, Inc.
Electric Power Research Institute, Inc.
GE Energy
NovelEdge Technologies LLC
Siemens
SOFCo Holdings, EFS
The Pennsylvania State University
University of Pennsylvania

## COST

**Total Project Value**
$149,017,422

**DOE/Non-DOE Share**
$86,097,518 / $62,919,904

and performance targets for stand-alone, tonnage-quantity, commercial ITM Oxygen plants and integration schemes of ITM Oxygen with IGCC and other advanced power generation systems.

Phase II activities were focused on testing the performance of full size ITM Oxygen modules in a 5-TPD ITM Oxygen Sub-Scale Engineering Prototype (SEP) facility specially designed for this purpose. The tests generated process information for the current Phase III activity, which will culminate in the design, construction, and operation of a 150-TPD Intermediate Scale Test Unit (ISTU) facility. Planned ISTU operations include producing high-purity oxygen at targeted production flux and qualifying process schemes for turbo machinery-integrated operation.

## Accomplishments

### Phase I

- Developed and demonstrated novel ITM materials for cost-effective oxygen separation that met the commercial flux target under anticipated commercial operating conditions
- Re-confirmed significant overall cost benefits over conventional, cryogenic oxygen production technology

### Phase II

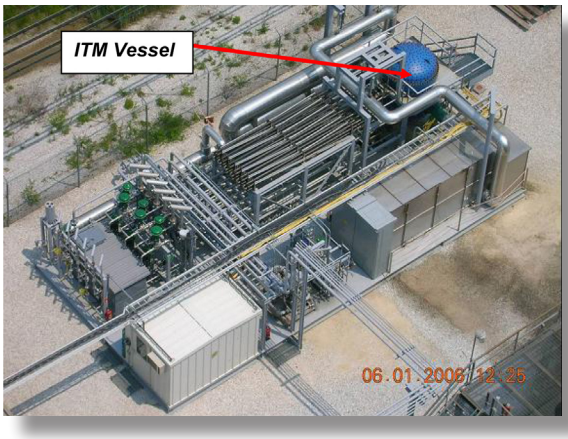
- Fabricated thin, cost-optimized, multi-layer ITM devices that achieved oxygen production rates exceeding commercial performance targets at anticipated commercial operating conditions with significant engineering lifetime.
- Scaled up and produced commercial-size wafers in large quantities
- Built and tested the first commercial-scale ITM Oxygen separation modules
- Designed, constructed and operated the 5-TPD SEP to verify the performance of commercial-scale modules

### Phase III

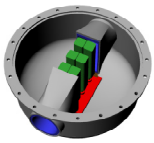
- Several thousand hours of testing have been logged at the 5-TPD ITM Oxygen SEP facility to allow engineering assessments for scale-up and commercialization.
- Completed the conceptual designs for both the 150-TPD ISTU vessel design and the oxygen separation module

## Benefits

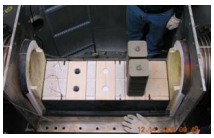
The ITM Oxygen production technology is a radically different approach to producing low-cost, high-quality tonnage oxygen, which will enhance the performance of IGCCs that produce coal-derived synthesis gas (a mixture of hydrogen and carbon monoxide) that can be burned in a combustion turbine or used to produce clean transportation fuels and hydrogen fuel. System studies confirm the ITM benefits on IGCC including a reduction of the IGCC plant specific cost dollars per kilowatt ($/kW) by 9 percent with a net power Megawatt electric (MWe) increase of 15 percent, and the plant efficiency increase of 1.2 percent with over 25 percent ($/TPD) savings in oxygen production cost. Studies have indicated the use of ITM Oxygen in other applications, such as, oxygen-enriched combustion of coal and full oxycombustion. Other oxygen-intensive industries such as steel, glass, non-ferrous metallurgy, refineries, and pulp and paper would realize cost, environmental, and productivity benefits as a result of ITM Oxygen.




*5-TPD Sub-Scale Engineering Prototype installed and operating*



*ITM Vessel Internals*



*Flow Duct Installed*