NETL GASIFICATION SYSTEMS

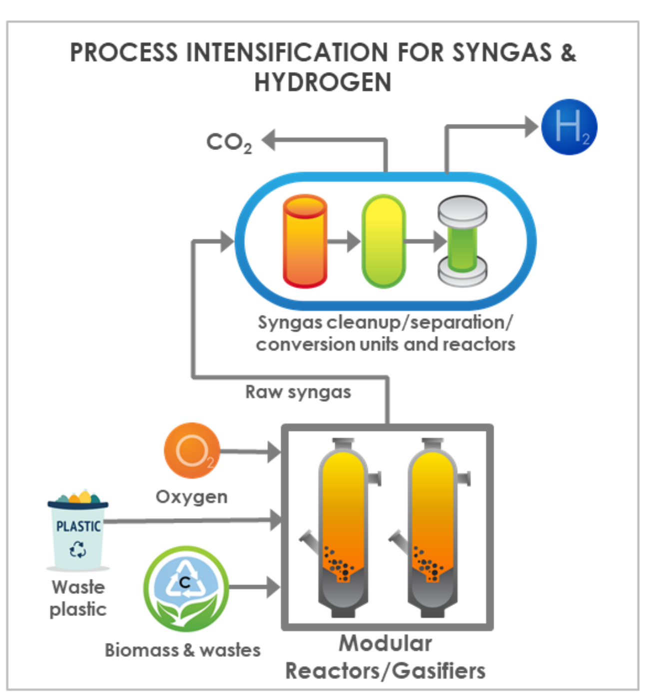
The Gasification Systems Program at NETL focuses on high-performance, modular, small-scale gasification systems to reduce investment risk, enhance reliability, and create alternative markets for coal through a diverse and cutting-edge research portfolio.

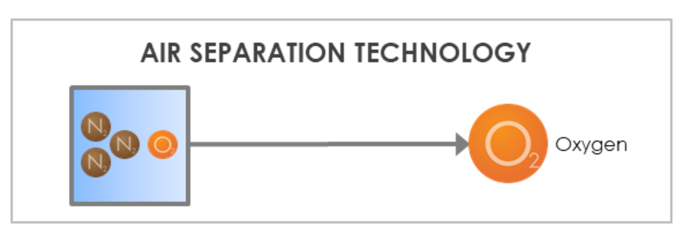
Gasification for A Decarbonized Economy

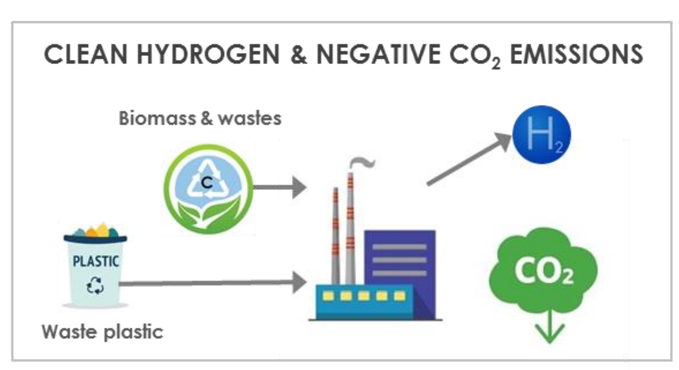
The DOE Gasification Systems Program is developing innovative modular designs for converting diverse types of feedstocks into clean synthesis gas to enable the low-cost production of electricity, transportation fuels, chemicals, hydrogen, and other useful products to suit market needs. Advancements in this area will help enable advanced power generation and other syngas-based technologies to be competitive in both domestic and international markets, and spur on the use of legacy waste materials and domestic biomass resources, in turn contributing toward increased energy security and reviving depressed markets in traditional coal-producing regions of the United States. Gasification technology development is supporting administration initiatives for the energy economy of the future.

Key Program Technology Areas

Improving gasifier designs to **increase syngas heating values, reduce reactor size,** and **lower oxygen demand for decarbonized energy systems and hydrogen production.**





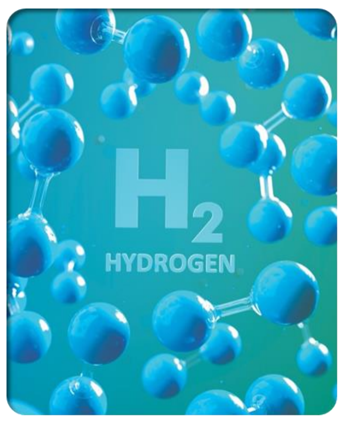


Innovative new methods for **oxygen production,** including **membranes, cryogenics,** and **oxygen carriers, enabling lowest cost carbon capture.**

Innovative technology for clean hydrogen production using **carbon-neutral** biomass with carbon capture, enabling net-negative carbon systems.

Clean Hydrogen

The gasification pathway enables deployment of clean hydrogen production with net-zero carbon or net-negative carbon capability in energy systems, and cost-effective decarbonization for U.S. industry. This helps to accomplish ambitious administration carbon reduction goals leading to complete decarbonization of the economy by 2050.



Environmental Justice

Gasification enables remediation of wastes (legacy waste disposal and more) to address environmental justice and job creation initiatives. Advanced co-gasification of wastes, biomass, and plastic with low-cost oxygen combine to form a viable net-zero energy system basis.

Decarbonized Economy

Process intensified gasification technologies with low-cost oxygen via advanced oxygen separation methods will enable lowest cost carbon capture, driving deployment and adoption of widespread carbon capture and storage as required for decarbonization.

GASIFICATION SYSTEMS

FY 2023 BUDGET REQUEST

$26,000k

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ERCo ENERGY RESEARCH COMPANY
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UNIVERSITY OF WYOMING
West Virginia University
AUBURN UNIVERSITY
UNIVERSITY OF KENTUCKY
EPRI ELECTRIC POWER RESEARCH INSTITUTE
Pacific Northwest NATIONAL LABORATORY
UNIVERSITY OF SOUTH CAROLINA
Los Alamos NATIONAL LABORATORY EST. 1943
TDA RESEARCH

Modularization of Ceramic Hollow Fiber Membrane Technology for Air Separation

Develop a membrane stack and module for air separation and oxygen production using an intermediate-temperature ceramic hollow fiber membrane

Overview

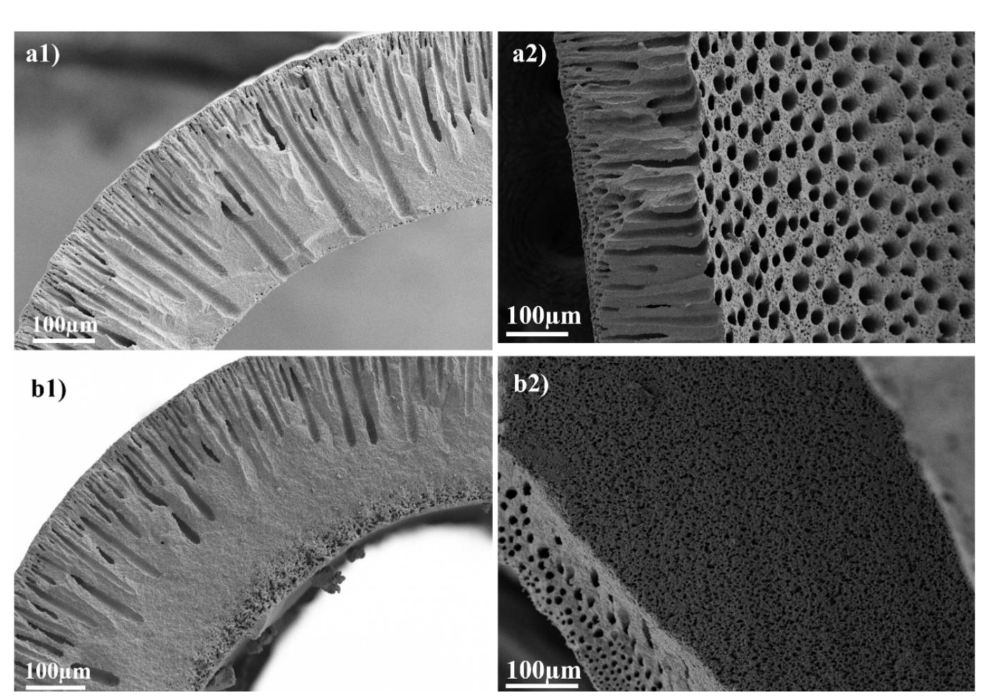
The University of South Carolina is developing intermediate temperature (<700°C), ceramic hollow fiber membrane (HFM) technology for efficient modular air separation. HFM-based oxygen production modules could be deployed with versatility in air separation applications for distributed gasification-based energy systems and beyond. The HFM technology development is on thin film, mixed conducting materials with high electrochemical kinetic properties, improving oxygen permeation flux while maintaining long-term operational stability of the HFM.

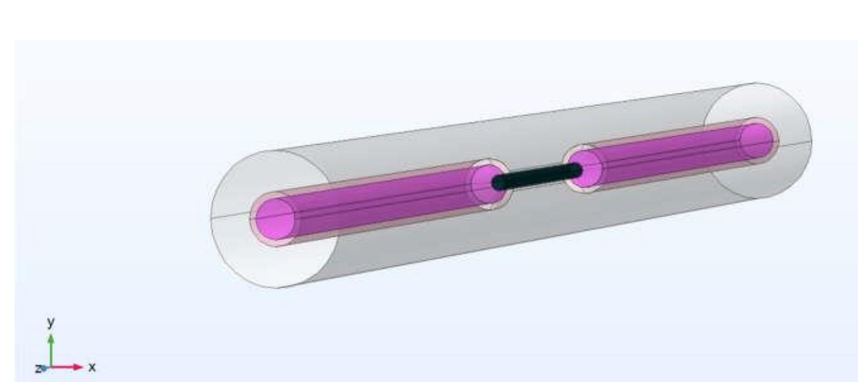
Benefits

Successful development of this technology may improve performance, reliability, and scale-up flexibility, as well as reduce capital and operating costs of smaller-scale oxygen production. These improvements could have broad impacts on the development of high-performance and durable air-separation technologies for decarbonized hydrogen production, net-zero or even net-negative carbon energy systems, as well as other oxygen-intensive industries.

Recent Results

- Finished optimization of the process for fabricating the hollow fiber functional layers
- Comprehensive measurement and evaluation of single membrane performance (oxygen permeation & long-term stability testing)
- Candidate membranes were identified for membrane stack assembly





QUICK FACTS

AWARD NUMBER:
DE-FE0031473

PROJECT BUDGET

DOE Share:
$1,539k

Performer Share:
$393k

Total Award Value:
$1,932k

CONTACTS

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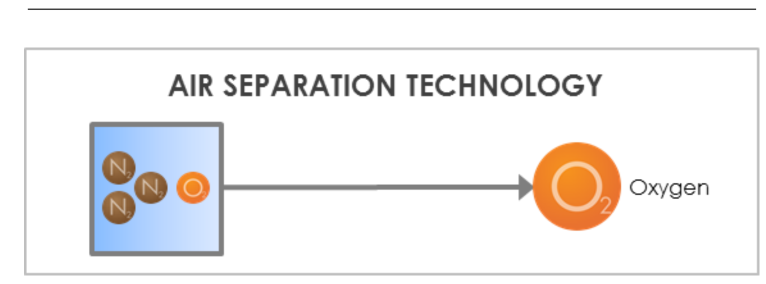
PARTNER

UNIVERSITY OF South Carolina



U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Fluidized-Bed Gasification of Coal-Biomass-Plastics for Hydrogen Production

Examine the gasification performance of coal, waste plastics, and southern pine mixture in a laboratory-scale fluidized-bed gasifier for hydrogen production

Overview

Auburn University is combining experimental and modeling research to study production of hydrogen from gasification of a coal-plastic wastes-biomass mixture to produce energy and fuels while reducing greenhouse gas emissions. The main objective is to examine the gasification performance of selected feedstocks mixture in a laboratory-scale fluidized-bed gasifier.

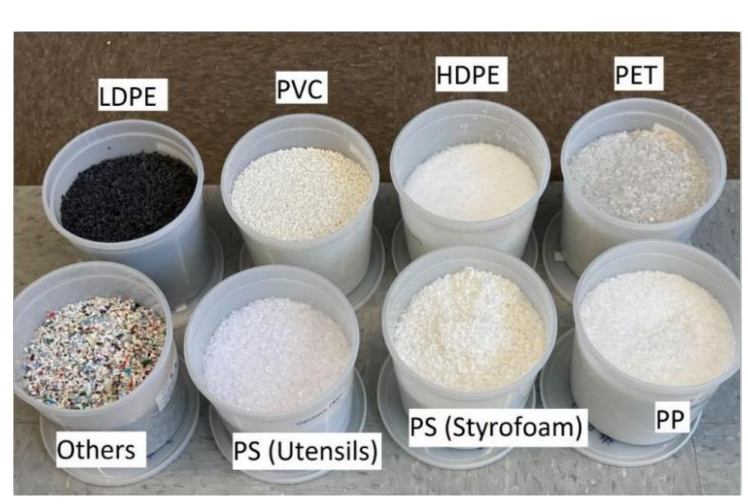
Specific objectives are to study coal-plastic-biomass mixtures in steam and oxygen environments; characterize the thermal properties of ash/slag from the mixture feedstock and investigate the interaction between slag/ash and refractory materials; and develop process models to determine the technology needed for syngas cleanup and removing contaminants for hydrogen production. Flow properties for the coal-plastics-biomass mixture will be measured. Syngas composition will be analyzed for permanent gases such as carbon monoxide, carbon dioxide, methane, and hydrogen along with contaminants such as tar, hydrogen sulfide, carbonyl sulfide, and ammonia.

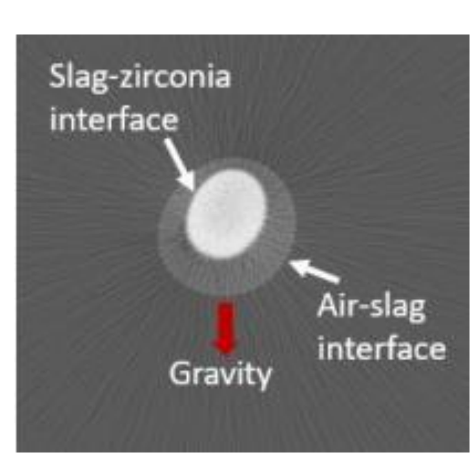
Benefits

By modeling the process, a process design for hydrogen production from coal, biomass, and waste plastics gasification will be achieved. The comparison of emerging advanced technologies with conventional state-of-the-art technologies for syngas clean up and conditioning, as well as the estimation of capital and operating costs for hydrogen production from selected wastes are two other benefits of the project.

Recent Results

- Waste plastics samples were shredded, sieved, and ground using a cryogenic grinder
- Physical and flow characterization of ground plastics, coal, and biomass samples were performed
- Thermal value, chemical analysis, and ash fusion temperatures were measured
- Experimental gasification apparatus was fabricated
- Gasification behavior (ash/slag melting, thermal conductivity, slag-refractory reactivity) were studied





QUICK FACTS

AWARD NUMBER:
DE-FE0032041

PROJECT BUDGET

DOE Share:
$449k

Performer Share:
$127k

Total Award Value:
$626k

CONTACTS

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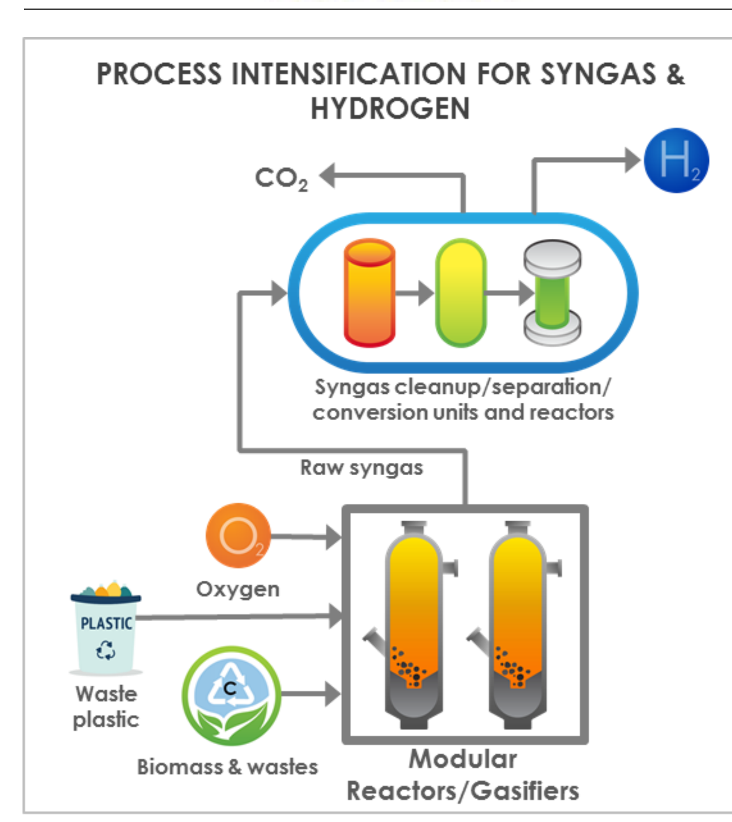
PERFORMER

AUBURN UNIVERSITY



U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Enabling Entrained Flow Gasification of Blends of Coal, Biomass, and Plastics

Demonstrate technical feasibility of gasifying blends of coal, biomass, and mixed waste plastics in an entrained-flow gasifier for production of H_2 with potential for net negative CO_2 emissions

Overview

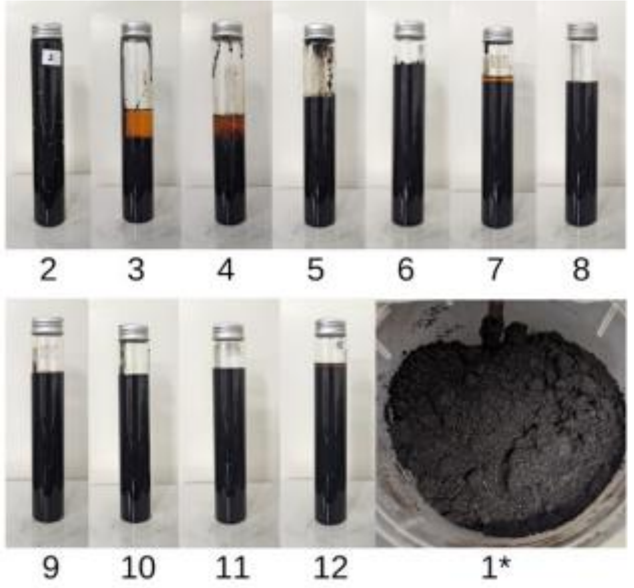
The University of Utah will leverage a high-pressure, slurry-fed, oxygen-blown entrained-flow system to enable co-gasification of biomass and waste plastic by creating slurries of pulverized coal, biomass pyrolysis liquids, and liquefied plastic oil. Objectives include determining compositions of coal-biomass-plastic mixtures that produce a stable slurry suitable for pumping to high pressure, designing and testing a novel burner to effectively atomize the mixed feedstock slurry in a pressurized gasifier, and acquiring first-of-a-kind performance data for pressurized, oxygen-blown entrained-flow gasification of slurred blends of coal, biomass, and plastic. Various combinations of coal, bioliquid, and plastic oil will be mixed to create blended feedstock slurries ranging from 25 to 60% biomass on a heating value basis. Gasification performance of the most promising slurry mixtures will be evaluated in the University of Utah's 1 ton/day pressurized oxygen-blown gasifier with the Hot Oxygen Burner (HOB) installed.

Benefits

The Gasification Systems Program efforts to generate lab-scale data and experience for co-gasification of mixed solid feedstocks like biomass, coal, and carbonaceous mixed wastes such as plastics and municipal solid waste enables and encourages the advancement of Clean Hydrogen technologies. Specifically, the data and experience provided in these projects facilitates the integration of pre-combustion carbon capture and storage (CCS) into gasification processes. By featuring biomass in the blended feedstock, the integration of CCS provides the possibility for net-zero or net-negative carbon emissions. Advances in co-gasification of blended feedstocks can provide significant benefits as part of the efforts to reduce and eliminate carbon emissions from the electricity sector and other sectors of the U.S. economy.

Recent Results

- Qualitative assessments of mixed feedstock slurries are complete
- Favorable slurry mixtures were identified
- The design of the HOB is nearly complete
- Gasifier modeling was performed using FactSage thermodynamic modeling software



QUICK FACTS

AWARD NUMBER:

DE-FE0032042

PROJECT BUDGET

DOE Share:

$500k

Performer Share:

$291k

Total Award Value:

$791k

CONTACTS

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ENSYN
EASTMAN
Linde
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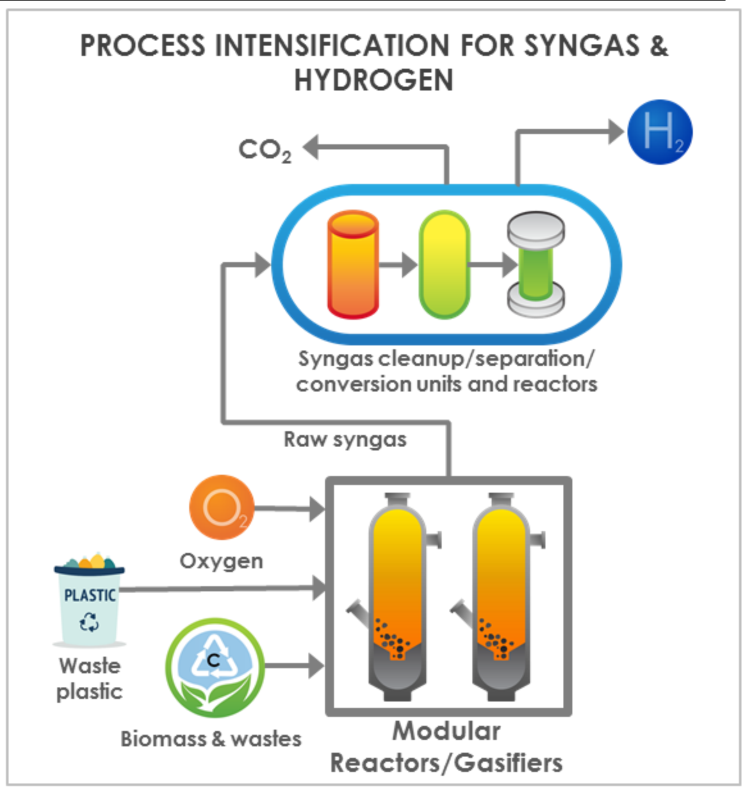


U.S. DEPARTMENT OF ENERGY
NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Development and Characterization of Densified Biomass-Plastic Blend for Entrained Flow Gasification

Develop and study a mixed fuel of coal, biomass, and plastic with a surface area <10 m^2/gram that is suitable for oxygen-blown entrained flow gasification with slurry feed

Overview

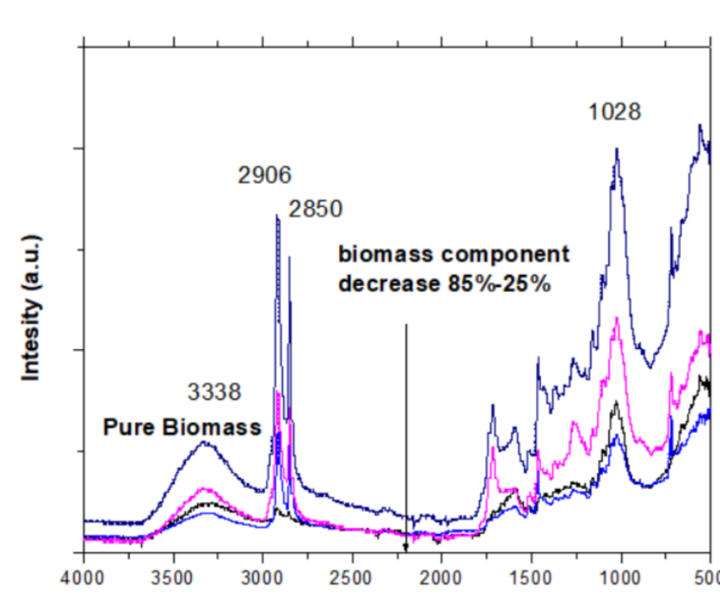
The University of Kentucky Research Foundation will utilize the existing thermogravimetric analysis-mass spectrometer, pyro-gas chromatography, 1.5" drop tube furnace, 1 ton per day coal gasifier, and a high-pressure extruder/pelletizer operated at the University of Kentucky Center for Applied Energy Research (UK CAER) to develop and study a coal/biomass/plastic blend fuel. UK CAER will mostly focus on the gasification of coal-plastic-biomass for reducing CO_2 emissions and the production of syngas and H_2. The Department of Energy believes that advances in co-gasification of coal, biomass, and waste plastics for polygeneration facilities and hydrogen can lead to a viable technology for low-carbon energy.

Benefits

Making advances in co-gasification of coal, biomass, and waste plastics for polygeneration facilities and hydrogen production can lead to a viable technology for low-carbon energy. The technology will also provide co-generation with electric power or heat and reduce CO_2 emissions. Utilizing plastic wastes offer high calorific heating values, and the biomass feedstocks are available and sourced. Overall, this technology will bring social justice and economic development for the coal production region.

Recent Results

- Densified biomass produced with at least 20% improvement of hydrophobicity and density
- Plastic encapsulated biomass was demonstrated
- Acceptable coal/biomass/plastic solid fuel slurry was demonstrated



QUICK FACTS

AWARD NUMBER:
DE-FE0032043

PROJECT BUDGET

DOE Share:
$500k

Performer Share:
$126k

Total Award Value:
$626k

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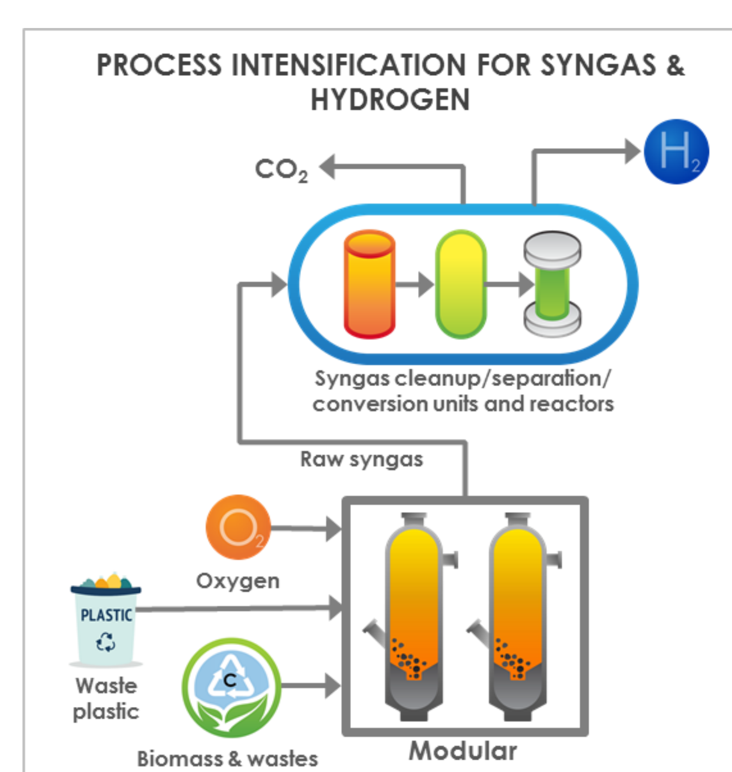

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Performance Testing of a Moving-Bed Gasifier Using Coal, Biomass, and Waste Plastics to Generate White Hydrogen

To qualify coal, biomass, and plastic waste blends based on performance testing of selected pellet recipes in a laboratory-scale updraft moving-bed gasifier

Overview

The overall goal of this project, led by Electric Power Research Institute, Inc. (EPRI), is to qualify coal, biomass, and plastic waste blends based on performance testing of selected pellet recipes in a laboratory-scale design of the moving-bed gasifier to be able to successfully use these feedstocks to produce hydrogen. In particular, the effects of waste plastics on feedstock development and the resulting products will be a focus. Providing data for an established gasifier will help accelerate its updated design to be able to accommodate feedstocks composed coal, biomass, and plastic waste, and will lead to a lower cost, white hydrogen generation system being commercial sooner.

Benefits

The Gasification Systems Program efforts to generate lab-scale data and experience for co-gasification of mixed solid feedstocks like biomass, coal, and carbonaceous mixed wastes such as plastics and municipal solid waste enables and encourages the advancement of Clean Hydrogen technologies. Specifically, the data and experience provided in these projects facilitates the integration of pre-combustion carbon capture and storage (CCS) into gasification processes. By featuring biomass in the blended feedstock, the integration of CCS provides the possibility for net-zero or net-negative carbon emissions.

Recent Results

- Finalized the coal, biomass, and waste plastics selection
- Finalized the pellet formations, with a total of 9 fuel mixtures

QUICK FACTS

AWARD NUMBER:
DE-FE0032044

PROJECT BUDGET

DOE Share:
$500k

Performer Share:
$125k

Total Award Value:
$625k

CONTACTS

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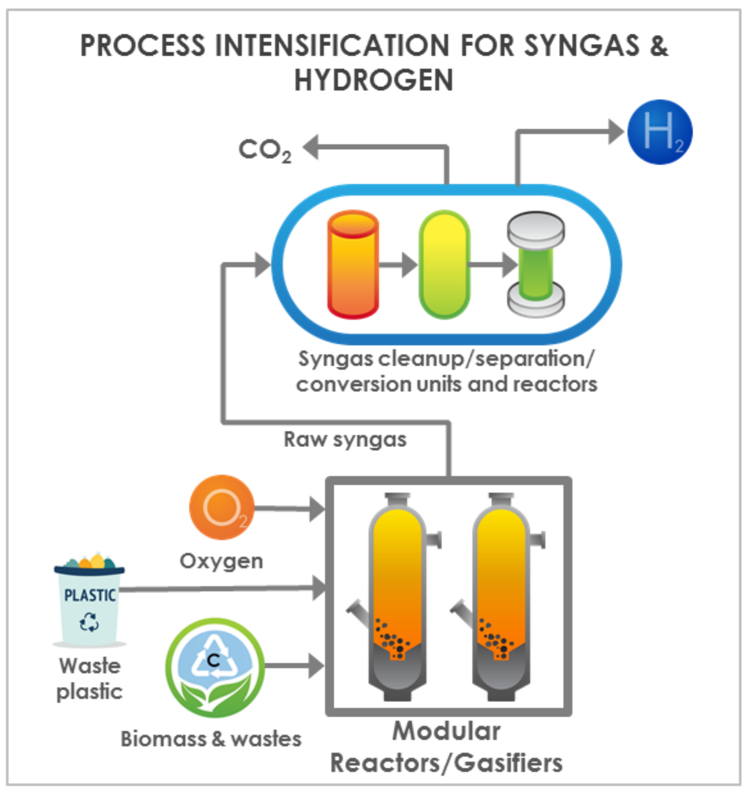
EPRI ELECTRIC POWER RESEARCH INSTITUTE



U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

A Mid-Century Net-Zero Scenario for the State of Wyoming and its Economic Impacts

Examine how fossil energy production will create an economic impact, as well as provide predictions for future energy mixes

Overview

The University of Wyoming will examine the economic impact of fossil energy production in Wyoming and provide various predictions for future energy mixes to achieve net-zero emissions. Specifically, the project will focus on critical aspects to reduce carbon emissions and facilitate the deployment of a clean hydrogen industry. Preliminary work suggests that Wyoming-based hydrogen production could have large economic benefits and job creation implications for Wyoming. The proposed study will further assess Wyoming's opportunities to create decarbonized hydrogen-based industries, assess economic impacts, identify knowledge gaps and research needs, and create a Hydrogen Center of Excellence to accelerate commercialization and deployment.

Benefits

If successful, the project will result in a clean-energy transition pathway for a state whose key economic driver is the export of fossil-based energy products. Such work benefits the nation's commitment to combat climate change as it adds to more states transitioning to net-zero emission economies. Moreover, the project takes into consideration job creation opportunities and other potential benefits to underrepresented groups and local tribal nations.

Recent Results

- Evaluations of performance and cost of blue hydrogen production from natural gas and direct emissions and water use for blue hydrogen production, via thermodynamic process modeling and techno-economic analysis
- Progress on developing an ArcGIS project including layers for resources that are related to potential development of hydrogen production, storage, and distribution in Wyoming and the region
- Coordination with Navajo Tribe-owned company Tosidoh LLC with plans to develop a local Hydrogen Hub on Navajo territories and develop a similar facility in Wyoming

QUICK FACTS

AWARD NUMBER:

DE-FE0032150

PROJECT BUDGET

DOE Share:

$644k

Performer Share:

$166k

Total Award Value:

$810k

CONTACTS

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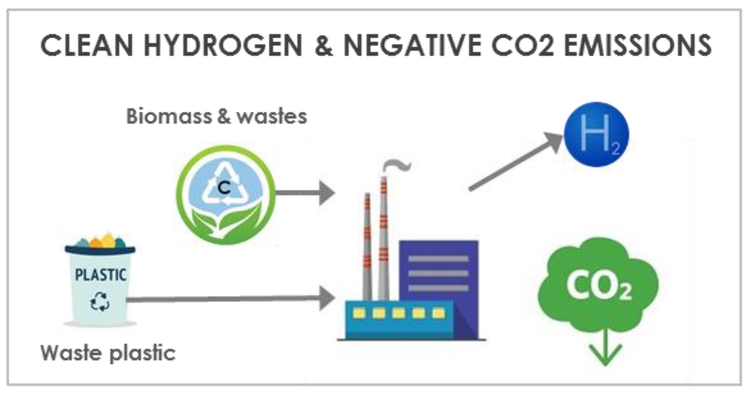
University of Wyoming



U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

Producing Clean Hydrogen Using a Modular Two-Stage Intensified Membrane-Enhanced Catalytic Gasifier

Develop a process intensified two-stage bubbling fluidized bed gasifier for hydrogen production from biomass

Overview

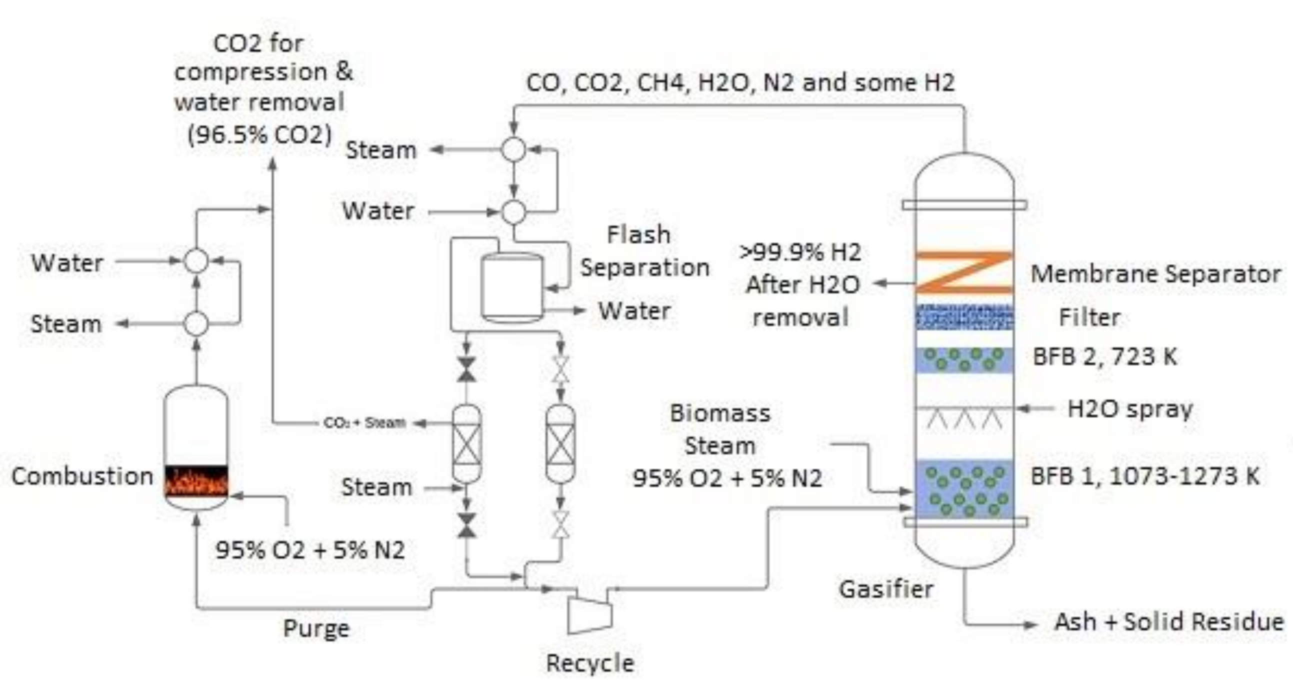
West Virginia University Research Corporation (WVURC) will develop a process intensified two-stage bubbling fluidized bed (BFB) gasifier for hydrogen production from biomass. As shown in the accompanying figure, WVURC will design and build a BFB gasifier system integrated with a membrane separator and pre-combustion carbon dioxide capture system with syngas recycle. The overall goal of the project is to reduce the costs of hydrogen production by developing a modular and highly efficient and intensified gasification system with significantly less equipment items than traditional systems.

Benefits

Awards resulting from DE-FOA-0002400, "Clean Hydrogen Production, Storage, Transport and Utilization to Enable a Net Zero Carbon Economy," are targeted toward developing technologies enabling clean hydrogen production, transport, storage, and use in the energy sector, including electricity, heat, transportation, and industrial use. These awards are focused on achieving overall cost reductions in clean hydrogen production from efficient gasification systems to make progress toward DOE's Hydrogen Shot initiative's cost goal of $1 per one kilogram of clean hydrogen. Advances in hydrogen technologies capable of improving performance, reliability, and flexibility of existing and novel methods to produce, transport, store, and use hydrogen will enable carbon footprint reductions associated with energy use, supporting the United States' goals to reduce greenhouse gas pollution by 2030 and to achieve economy-wide net-zero emissions by 2050.

Recent Results

- Project started October 2022. No results reported



QUICK FACTS

AWARD NUMBER:

DE-FE0032191

PROJECT BUDGET

DOE Share:

$1,499k

Performer Share:

$375k

Total Award Value:

$1874k

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West Virginia University

CLEAN HYDROGEN & NEGATIVE CO2 EMISSIONS

U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

Catalytic Membrane Reactors Based on Carbon Molecular Sieve Hollow Fiber Membranes for Sustainable And Modular Hydrogen Production

Examine how fossil energy production will create an economic impact, as well as provide predictions for future energy mixes

Overview

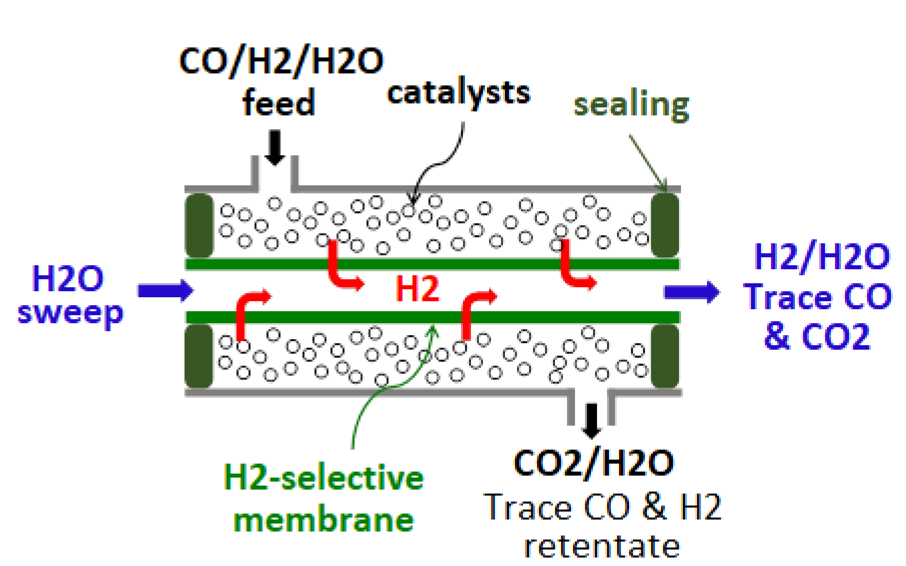
The Research Foundation for State University of New York (SUNY) on behalf of University at Buffalo will develop a process-intensified gasification system for economically viable, modular H_2 production from waste biomass using catalytic membrane reactors (CMR) based on carbon molecular sieve (CMS) hollow fiber membranes (HFMs). Specifically, the CMR will be developed to selectively remove H_2 during the high-temperature water-gas shift (WGS) reaction to circumvent thermodynamic limitations on the conversion of CO to CO_2 and H_2. The endpoint of the program will be a 200-hour continuous test of the optimized CMRs for achieving high carbon conversion at high temperatures and a roadmap for technology demonstration, deployment, and commercialization.

Benefits

Awards resulting from DE-FOA-0002400, "Clean Hydrogen Production, Storage, Transport and Utilization to Enable a Net Zero Carbon Economy," are targeted toward developing technologies enabling clean hydrogen production, transport, storage, and use in the energy sector, including electricity, heat, transportation, and industrial use. These awards are focused on achieving overall cost reductions in clean hydrogen production from efficient gasification systems to make progress toward DOE's Hydrogen Shot initiative's cost goal of $1 per one kilogram of clean hydrogen. Advances in hydrogen technologies capable of improving performance, reliability, and flexibility of existing and novel methods to produce, transport, store, and use hydrogen will enable carbon footprint reductions associated with energy use, supporting the United States' goals to reduce greenhouse gas pollution by 2030 and to achieve economy-wide net-zero emissions by 2050.

Recent Results

- Project started October 2022. No results reported



Schematic of catalytic membrane reactors (CMRs)

QUICK FACTS

AWARD NUMBER:
DE-FE0032209

PROJECT BUDGET

DOE Share:
$1,600k

Performer Share:
$500k

Total Award Value:
$2,100k

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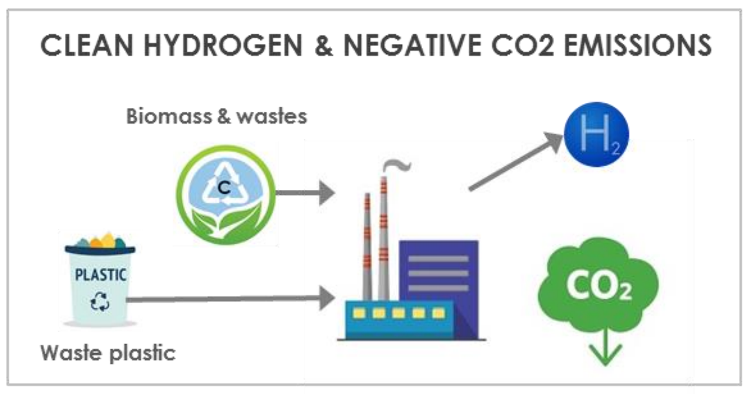
SUNY The State University of New York



U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Advanced Gasifier Design

Leveraging NETL's multiphase computational modeling expertise in reactor design problems, and utilizing MFiX and other key software tools

Overview

NETL's simulation-based engineering tools (MFiX, Optimization Toolset, etc.) will be used for design and optimization of novel pyrolysis and gasification reactor designs supporting DOE's Office of Fossil Energy and Carbon Management (FECM) mission. Simulations will be performed to guide design and scale-up of gasification reactors for mixed feedstocks, including biomass, plastics, and municipal solid waste. Simulations will verify that the pilot-scale system will meet the required design parameters and help guide reactor optimization. NETL multiphase flow computational fluid dynamics (CFD) tools and reactor expertise will be used to study and develop novel gasification-based designs to address FECM's hydrogen strategy goals. NETL will look at the fundamentals of co-pyrolysis and co-gasification of mixed feedstocks for maximizing H_2 production and minimizing CO_2 emissions.

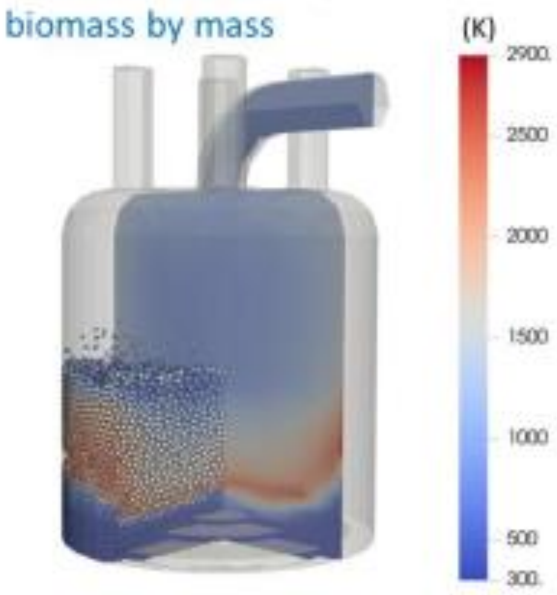
Benefits

In this research effort, NETL is providing an advanced capability to use reactor performance predictions from multiphase flow CFD simulations to optimize reactor performance. In contrast to proprietary commercial CFD software, the MFiX Suite and associated toolsets are open-source codes, freely available to FECM stakeholders from industry and universities. Furthermore, the codes are developed, validated, and supported for FECM applications by NETL's software development and application specialists, who have expertise in the application of CFD tools to FECM technologies. As an open-source code, the MFiX Suite can be customized for novel applications.

Recent Results

- Simulations were performed on a gasifier with coal/biomass mixtures to determine operating conditions for hydrogen production with net-zero carbon emissions
- Re-Injection of tar into a gasifier was modeled and found to create local regions of high temperature, which crack the tar and increase the rates of gasification and char/tar oxidation reactions

Base Case: 90% coal/10% biomass by mass



QUICK FACTS

AWARD NUMBER:
NETL FWP 1022405, Task 3

PROJECT BUDGET

DOE Share:
$4,200k

Total Award Value:
$4,200k

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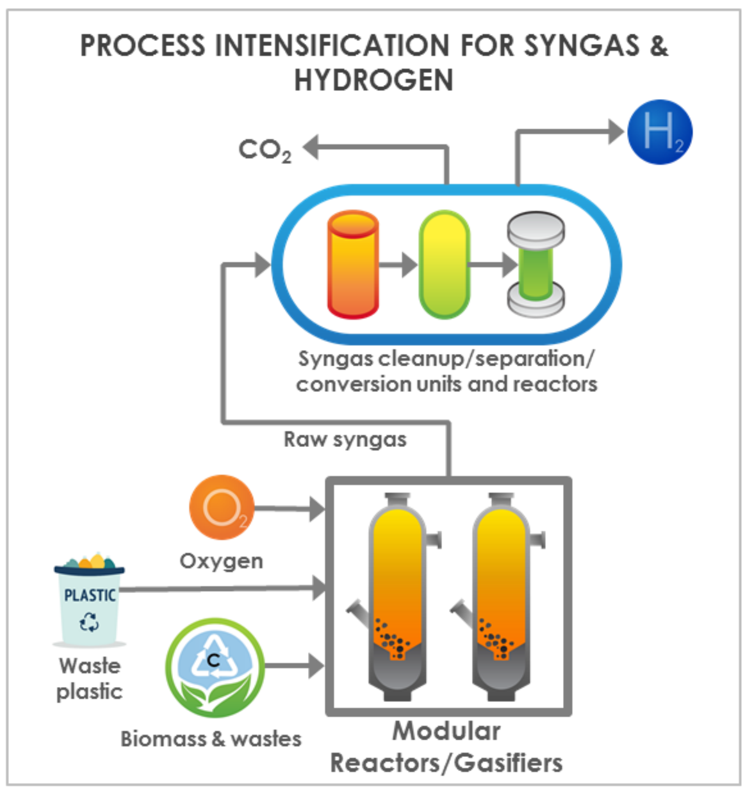
PRINCIPAL INVESTIGATOR:
William Rogers

PERFORMER

NETL



Refractory Materials for Multi-Fuel Gasification

Identify construction materials and manufacturing technologies to build small-scale computer-modeled ARS gasification modules

Overview

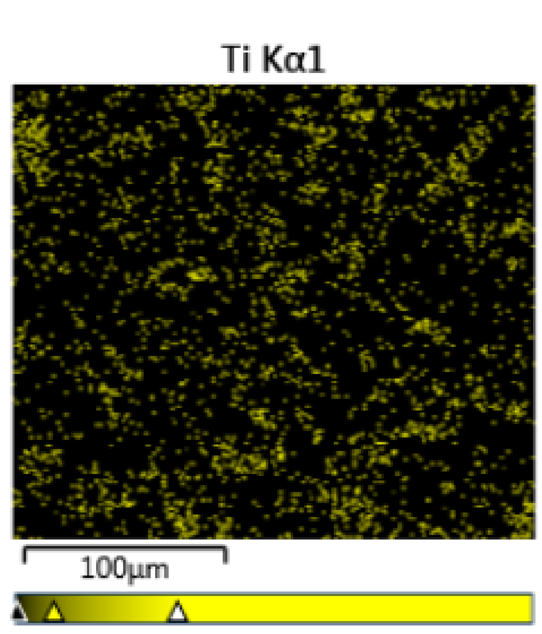
The objective of this effort is to identify materials of construction and manufacturing technologies to build small-scale computer-modeled gasification modules that will meet system performance requirements in laboratory studies (temperatures up to 1,200°C, coal as the primary carbon feedstock, an initial targeted material throughput of one ton/hour, and an initial service life of 500 hours). Samples of both reaction chamber and carbon feedstock materials, and the reaction system products/byproducts, will be evaluated to validate and modify computer models that are being leveraged to aid in synergistic research and development across tasks.

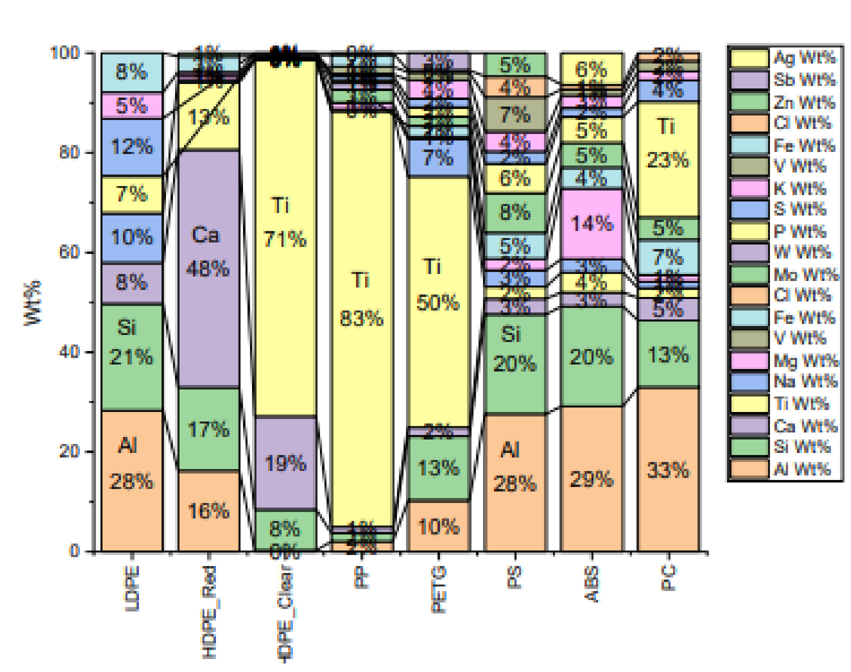
Benefits

Advances in technology will allow construction of gasification systems using effective combinations of metals (to confine the process and support the reaction chamber structure) and refractory ceramics (to withstand and confine the harsh high-temperature reaction chamber environment against wear and corrosion). This will help enable systems to have low costs of construction, predicable system performance and service life, and efficient and cost-effective operation.

Recent Results

- Developed a plastic ash composition database for various plastic types
- Two refractory compositions were successfully identified to be used in mixed coal-biomass modular gasifier environments





QUICK FACTS

AWARD NUMBER:
NETL FWP 1022405, Task 4

PROJECT BUDGET

DOE Share:
$1,146k

Total Award Value:
$1,146k

CONTACTS

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TECHNOLOGY MANAGER:
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FEDERAL PROJECT MANAGER:
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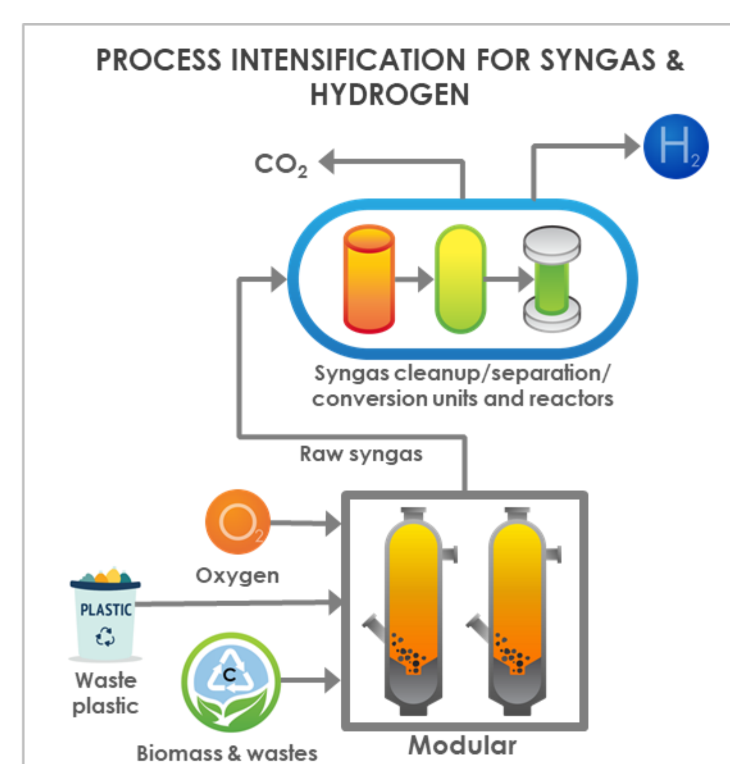
PRINCIPAL INVESTIGATOR:
Omer Dogan

PERFORMER

NETL



Oxygen Integration for Net-Zero Carbon

Development of tailored oxygen carrier materials for oxygen production for gasification reactions and other applications

Overview

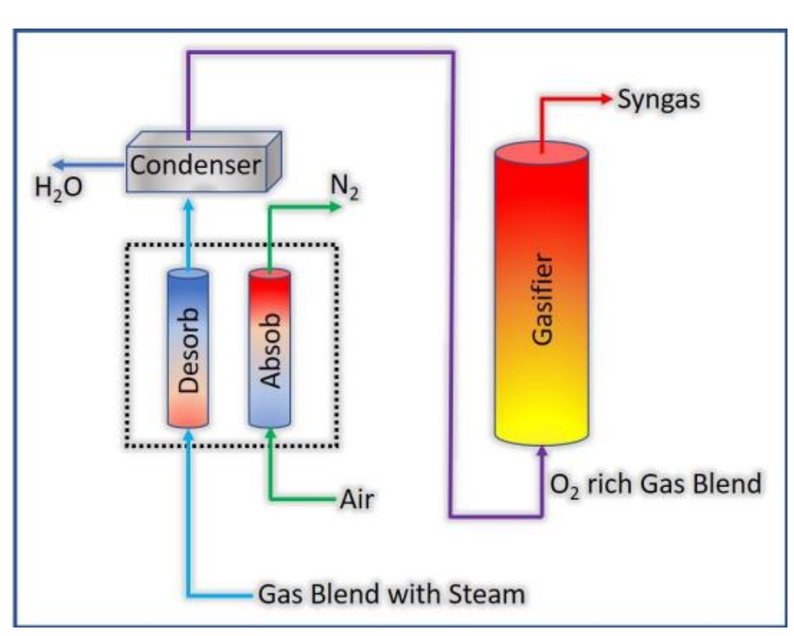
This task is developing tailored oxygen carrier materials for uses in an oxygen production module that can be added to a gasification system as an in-situ source of oxygen for gasification reactions. These carrier materials will have tunable oxygen delivery properties to respond to a variety of opportunities and fuels. Aside from innovative carrier materials, designs for an oxygen production module and an optimized process to produce syngas using a combination of coal and oxygen carriers are under development.

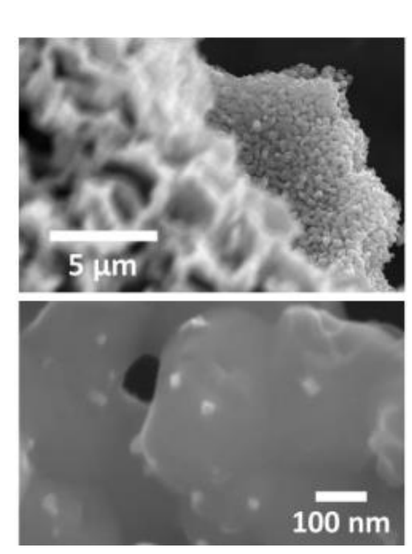
Benefits

The modular systems that are currently being studied could benefit from the use of an oxygen carrier material if that carrier can be made competitive with a scaled-down cryogenic process in terms of cost and efficiency. Perovskite materials under development as carriers are favorable as a type of stable material that can rapidly and reversibly store and release large quantities of oxygen due to their nonstoichiometric nature. Ferrite materials under development have been shown to have thermodynamics that favor the partial oxidation of coal to carbon monoxide instead of the complete oxidation to carbon dioxide, which makes them ideal for gasification reactions.

Recent Results

- Demonstrated the ability to control capacity, desorption temperature, and rate through compositional changes
- Designed and tested a carrier with greater than 2.0 percent weight (wt%) oxygen capacity with rates in excess of 2 wt% per minute and demonstrated stability over more than 10,000 cycles
- Ellingham diagrams for perovskite carriers were calculated and experimentally validated
- A preliminary reactor design was completed using NETL's MFiX software





QUICK FACTS

AWARD NUMBER:

NETL FWP 1022405, Task 5

PROJECT BUDGET

DOE Share:

$1,550k

Total Award Value:

$1,550k

CONTACTS

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PERFORMER

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Microwave Reactions for Gasification

Develop microwave technology for fuel-flexible gasification at a modular scale

Overview

The National Energy Technology Laboratory (NETL) is developing microwave-based concepts for fuel-flexible gasification at a modular scale. Co-production of energy, value-added chemicals, and carbon materials at low temperature is enhanced with microwave application to blended feed streams of biomass, waste plastic, coal fines, and/or municipal solid waste. The objective of this task is to design an efficient microwave gasification process that can handle heterogeneous feedstock and quantify the energy efficiency and economic benefits of new design approaches to integrate microwave technology into different steps in the gasification process (e.g., feed pretreatment, tar conversion). Specifically, the degree of interaction of various microwave fields with reaction intermediates, catalysts, or other microwave-active materials will be measured as a function of microwave power, pulse, and frequency, as well as reactor temperature and gas compositions. Thorough mechanistic studies will be performed to evaluate reaction pathways in microwave-assisted gasification of waste plastic/biomass.

Benefits

Chemical conversion can be enhanced by applying microwave fields to the reaction zone. The high-frequency microwave fields can selectively stimulate active sites in metals through dielectric and magnetic interactions without increasing the bulk gas temperature and solid medium. These conditions can result in product yields that are significantly higher than predicted by thermodynamics, which can provide savings in both energy and feed costs.

Recent Results

- Complete gasification and high hydrogen production with mixed plastic and biomass was achieved
- A low production of H_2 and incomplete gasification were results of using plastic only, confirming synergy
- The reaction time for complete gasification was reduced to about 15 minutes for a 6-gram sample

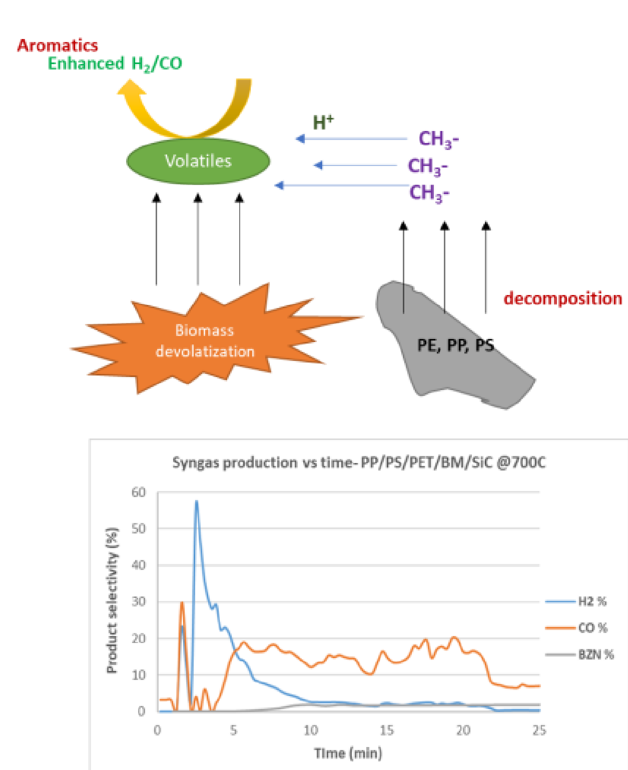

Fig. Product Selectivity of plastic (3g) and biomass (1g) MW gasification with SiC (2g), 200 SCCM air, 700°C

QUICK FACTS

AWARD NUMBER:

NETL FWP 1022405, Task 6

PROJECT BUDGET

DOE Share:

$2,503k

Total Award Value:

$2,503k

CONTACTS

HQ PROGRAM MANAGER:
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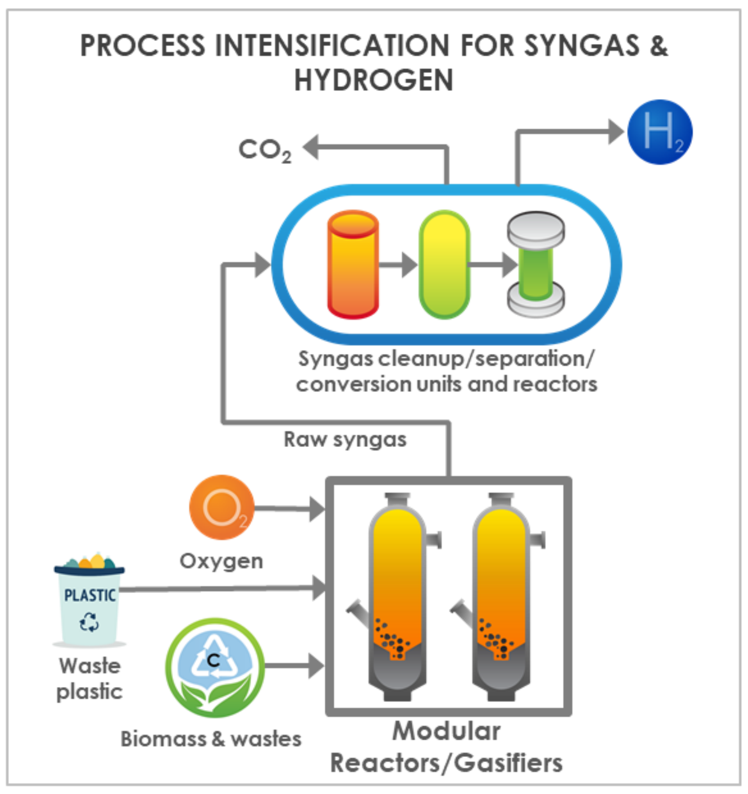

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Process Development to Mature Oxygen Sorbent-Based Technology

Develop a computational model that captures the oxygen storage and release potential of NETL designed materials to design a pilot-scale fixed bed reactor

Overview

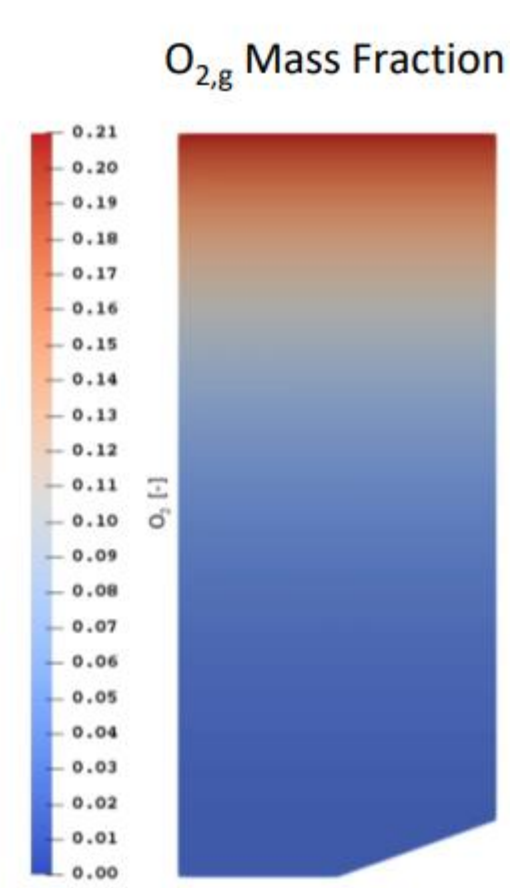
The National Energy Technology Laboratory (NETL) is focused on developing a computational model that captures the storage and release potential of oxygen of NETL designed materials. The computational method can also be used to leverage simulation in designing a pilot-scale fixed bed, perovskite sorbent oxygen separation reactor. A model pilot-scale prototype of a fixed bed, perovskite sorbent O_2 separation unit will be developed using simulation-based engineering tools. The model will include both O_2 capture and regeneration modes of operation with thermal management of the system using heat exchange surfaces in fixed beds. Model predictions will be validated with experimental data. The model will be exercised over a range of operating conditions, including flow and temperature.

Benefits

In this research effort, NETL is providing an advanced capability to use reactor performance predictions from multiphase flow computational fluid dynamics (CFD) simulations to optimize reactor performance. These virtual "experiments" allow simulation-based optimization of reactors using multiphase flow CFD simulations. This capability will use multi-objective optimization techniques in conjunction with reacting multiphase flow CFD simulations to determine optimal designs to support energy reactors.

Recent Results

- NETL scientists ran thermogravimetric analysis experiments over a range of O_2 gas concentrations and temperatures that were used to derive kinetic constants
- Multiple simulations of O_2 absorption and desorption were conducted to gain an understanding of how simple changes in a reactor mass loading can affect O_2 production in a fixed bed device



QUICK FACTS

AWARD NUMBER:
NETL FWP 1022405, Task 7

PROJECT BUDGET

DOE Share:
$1,300k

Total Award Value:
$1,300k

CONTACTS

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PERFORMER

NETL

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Gasification of Waste Plastic to Enable a Circular Economy

Develop a machine learning tool to predict gasification reactor performance based on feedstock and operating conditions

Overview

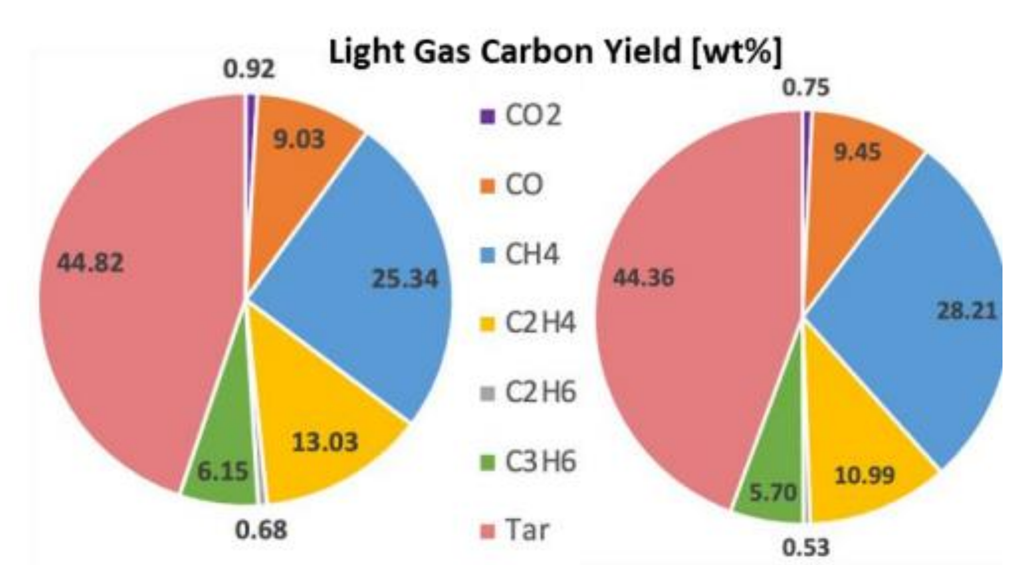
The objective of this effort is to explore the gasification of alternative carbonaceous feedstocks, such as waste plastic, waste coal, and biomass to generate H_2 with minimal CO_2 emissions. EY22 will focus on investigation of impact of operation conditions on H_2/syngas production and composition in co-gasification of waste plastic with waste coal and/or biomass to optimize H_2/syngas conversion.

Benefits

The team will explore the gasification of waste plastic/landfill waste with waste coal and/or biomass to generate low carbon footprint H_2. In the process, waste plastic mixed with waste coal and/or biomass will be fed into a gasifier to react with air, steam, and/or CO_2 at a high temperature (700°–1000°C) to form raw syngas (mixture of H_2, CO, and CO_2). After syngas cleanup, more H_2 will be produced via H_2O gas shift reactions. Concentrated H_2 will be produced after carbon capture operation and will be further converted to electricity or to chemicals like ethanol, methanol, and liquid fuels, which will reduce the reliance on imported petroleum. Captured CO_2 will be sent to storage or utilization plants.

Recent Results

- Studied the gasification of alternative feedstock of waste plastic and waste coal to generate enhanced H_2 and syngas in a drop tube reactor
- Identified key parameters for product composition, including temperature and residence time
- Analyzed approximately 10,000 papers on plastic recycling and upcycling to explore emerging trends using Big-data tools



Low-Density Polyethylene (LDPE) Polypropylene (PP)

QUICK FACTS

AWARD NUMBER:

NETL FWP 1022405, Task 8

PROJECT BUDGET

DOE Share:

$1,151k

Total Award Value:

$1,151k

CONTACTS

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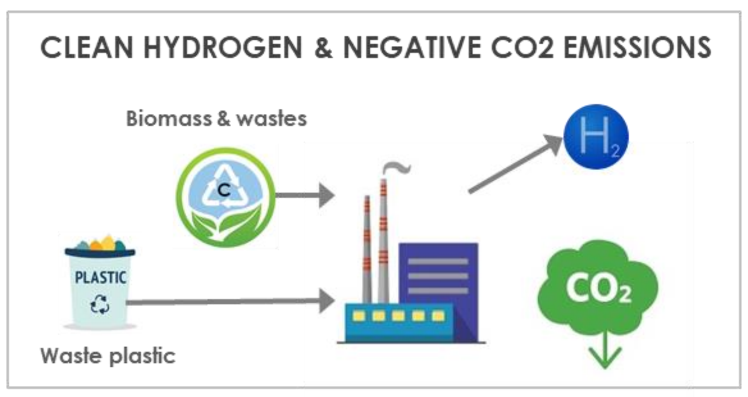


Pressure Driven Oxygen Separation

Development of air separation technology to be utilized in advanced coal-based modular energy systems, making substantial progress toward enabling cost-competitive, coal-based power generation with near-zero emissions

Overview

Pacific Northwest National Laboratory (PNNL) is developing air separation technology based on mixed ion-conducting membranes in planar architecture and stacks, employing doped CeO_2 as the ion conductor and $LaMnO_3$ as the electronic conductor supported on low-cost porous substrate of MgO-Al_2O_3 composites. This technology utilizes the difference in oxygen partial pressures across the membrane in an air separation unit to drive the separation of oxygen.

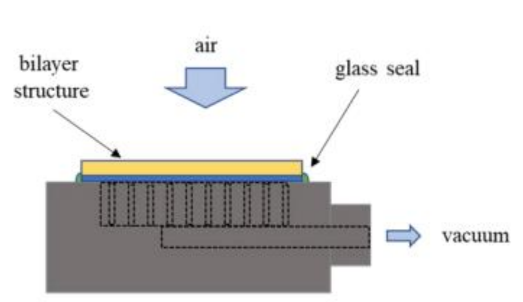
PNNL is focusing on multiple technological aspects for increasing performance efficiency and reducing costs of this technology, including best use of low-cost materials, planar stack architecture design allowing reliable and low-cost fabrication/processing and stack/seal performance, minimizing interactions between ionic and electronic conducting phases during sintering to maximize oxygen permeability in the composite membranes, and controlling sintering so as to minimize warping and cracking of the planar composite membranes.

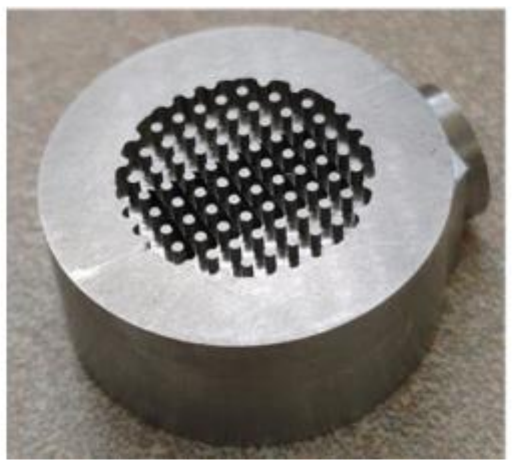
Benefits

This membrane-based oxygen separation approach is intended to enable small-scale, modular air separation units providing 10 to 40 tons of high-purity oxygen to 1- to 5-MWe gasifiers at low cost and high energy efficiency.

Because the air separation membrane is of the ion transport type, it provides extremely high oxygen selectivity. But unlike conventional ion transport membranes that require operating temperatures of 1,450 to 1,650°F, PNNL's membrane is targeted for operation at 1,100 to 1,300°F. At these milder conditions, energy demand for heating input gases is lower, and equipment durability should be improved.

Recent Results





- Fabricated 3-inch diameter bilayers that are flat and crack free that are capable of measuring O_2 permeability
- Verified this fabrication by developing and implementing a test plan to conduct O_2 permeation measurements to support accelerating scaleup of bilayer membranes for stack production

QUICK FACTS

AWARD NUMBER:

FWP-73130

PROJECT BUDGET

National Laboratory Share:

$2,650k

Total Award Value:

$2,650k

CONTACTS

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David Reed

PERFORMER

Pacific Northwest National Laboratory

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Magnetocaloric Cryogenic System for High-Efficiency Air Separations

Development of air separation technology to be utilized in advanced coal-based modular energy systems, making substantial progress toward enabling cost-competitive, coal-based power generation with near-zero emissions

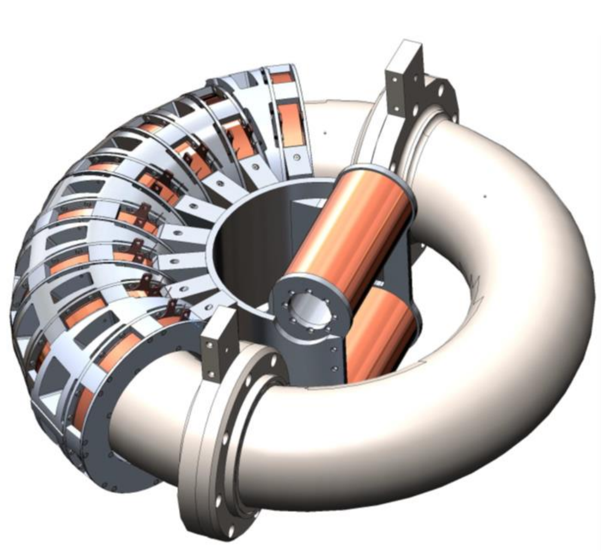
Overview

Pacific Northwest National Laboratory (PNNL) is developing the Magnetocaloric Oxygen Liquefier Systems (MOLS) technology in this project. MOLS uses magnetization and demagnetization of solids for refrigeration instead of conventional gas compression and expansion. The principle exploited is that highly reversible, adiabatic heating or cooling occurs in ferromagnetic materials near their Curie temperatures when they are subjected to large (approximately 6 to 7 Tesla) magnetic field changes. MOLS cycles these materials in and out of high magnetic fields, causing them to behave as solid-state refrigerants in a magnetic regenerative liquefaction cycle that minimizes the use of mechanical gas compression. MOLS results in liquefied air, which can then be subjected to conventional cryogenic distillation. Technology development focuses on attaining the temperature reduction over the required range (to a liquid air temperature of 100K) through identification and combination of multiple layers of refrigerant materials in suitable regenerator configurations and advancing superconducting magnet design and integration with the regenerator.

Benefits

Gas compressors and expanders in cryogenic air separation units (ASUs) are the major cost drivers of conventional air separation. MOLS almost entirely eliminates the need for conventional gas compression in cryogenic-based air separation. Preliminary cost analysis indicates that MOLS will be no more or even less expensive than the conventional liquefaction technologies used in cryogenic ASUs. Moreover, MOLS is highly modular, providing good cost performance for smaller amounts of oxygen production at which conventional cryogenic ASUs would have poor cost performance.

Recent Results



- Assembled and tested new liquid propane pump
- Improved MOLS to eliminate magnetic force and eddy current magnet heating
- Analyzed and designed microchannel distillers of ASU for small engineering scale
- Detailed design of magnetocaloric liquefier module for integrated ASU track

QUICK FACTS

AWARD NUMBER:
FWP-73143

PROJECT BUDGET

National Laboratory Share:
$2,650k

Total Award Value:
$2,650k

CONTACTS

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Pacific Northwest NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

High Selectivity and High Throughput Carbon Molecular Sieve Hollow Fiber Membrane Based Modular Air Separation Unit for Producing High Purity O_2

Development of air separation technology to be utilized in advanced coal-based modular energy systems, making substantial progress toward enabling cost-competitive, coal-based power generation with near-zero emissions

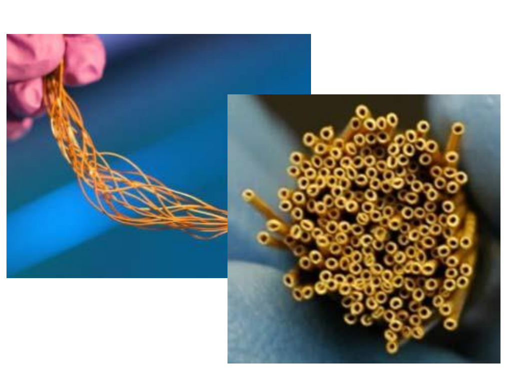
Overview

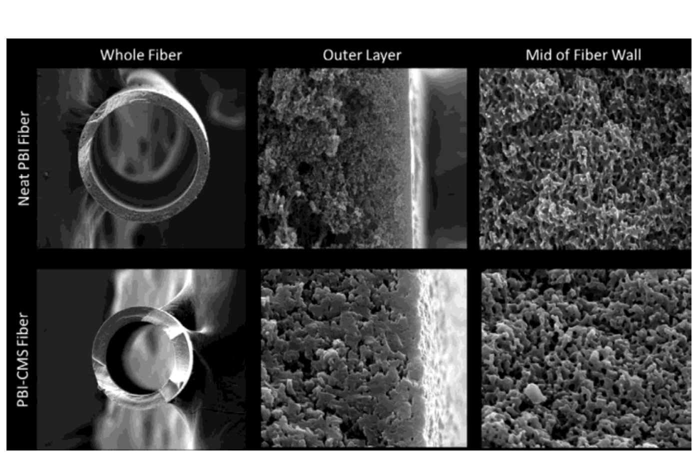
Los Alamos National Laboratory (LANL) is developing carbon molecular sieve (CMS) hollow fiber membranes for a modular air separation unit for high purity O_2 production. A two-stage membrane process is envisioned and will be optimized to achieve the O_2 purity target while minimizing the energy consumption. Core to the proposed work is development of polybenzimidazole (PBI)-derived CMS (PBI-CMS) hollow fiber membranes having exceptional O_2/N_2 selectivity and high O_2 permeance. The PBI-CMS hollow fiber membranes will be obtained via controlled pyrolysis of PBI hollow fibers having microstructures tailored for gas separations (PBI HF manufacturing methods recently discovered/patented by the LANL team).

Benefits

Membrane-based ASUs have better energy efficiency than industry-standard cryogenic methods, provided materials having high O_2/N_2 selectivity and high productivity membrane systems based on these materials are developed. PBI-CMS membranes have expectational separation performance potential, and when deployed in high packing-density and low-cost hollow fiber membrane modules familiar in industrial application, should enable energy-efficient high-purity O_2 production at modular scales.

Recent Results





- Determined goals for cost, permeability, and selectivity that can be reached by looking at what can be achieved for the material and process
- Set up a laboratory system with controlled pyrolysis conditions under flowing gas
- Argon testing was performed, determining the maximum possible O_2 purity

QUICK FACTS

AWARD NUMBER:

FWP-FE-1049-18-FY19

PROJECT BUDGET

National Laboratory Share:

$2,650k

Total Award Value:

$2,650k

CONTACTS

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Los Alamos NATIONAL LABORATORY EST. 1943

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Machine Learning Enhanced LIBS to Measure and Process Biofuels and Waste Coal for Gasifier Improved Operation

- In situ and near real time gasifier feedstock measurement, resulting in immediate and time sensitive fuel data that gasifier operators can use to maximize performance and avoid negative effects of ash in feedstocks

Overview

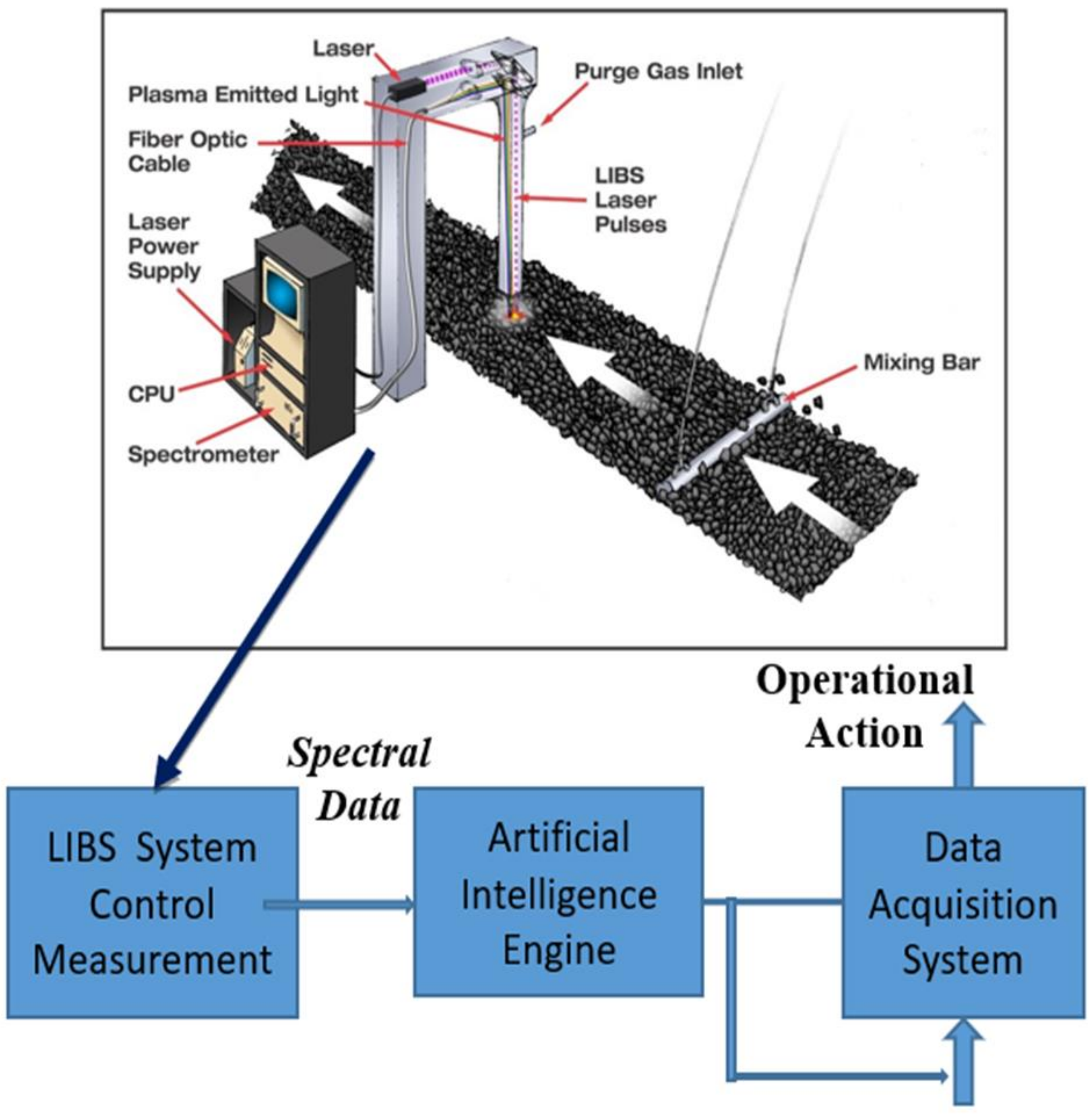
In this Phase I STTR, Energy Research Company will work with Lehigh University to develop an instrument to measure the feedstock to a gasifier in-situ and in near real time, resulting in immediate and time sensitive fuel data that gasifier operators can use in a feedback or feedforward control scheme to maximize performance and avoid negative effects of ash in feedstocks. The instrument will combine Laser Induced Breakdown Spectroscopy (LIBS) with Artificial Intelligence (AI). The specific objectives are to (1) measure the spectra of coal waste and biofuels in a laboratory setting, (2) develop AI algorithms for system data processing, which provide improvement in measurement accuracy, and (3) achieve an accuracy and precision that will provide commercial value.

Benefits

Technological advancement in this area would provide better control of gasification and ash/slag issues arising with complex mixed feedstocks. This would tend to help increase value from utilization of waste and biomass feedstocks as environmental justice and legacy waste remediation are pursued.

Recent Results

- Project awarded July 2022. No results reported



QUICK FACTS

AWARD NUMBER:
SC0022696

PROJECT BUDGET

DOE Share:
$250k

Total Award Value:
$250k

CONTACTS

HQ PROJECT MANAGER:
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Robert De Saro

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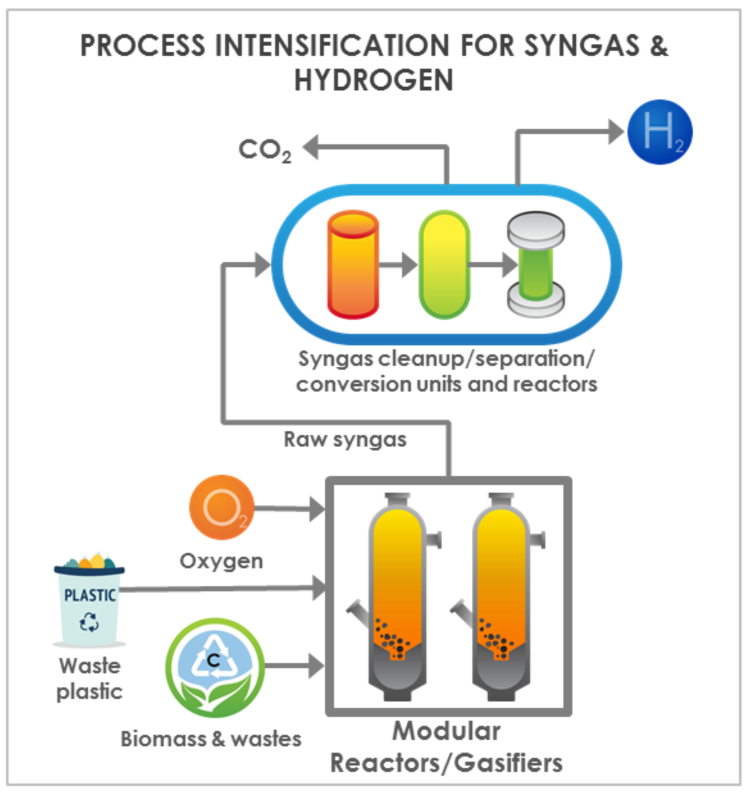
ERCo ENERGY RESEARCH COMPANY



U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Optimization of Coal Waste/Biomass Gasification for Hydrogen Production

- Development and application of tools to manage feedstock properties and to optimize gasification processes fostering utilization of challenging waste coal and biomass materials in gasification technologies to produce hydrogen

Overview

Microbeam Technologies Incorporated (MTI) will develop and utilize tools to manage feedstock properties and to optimize gasification processes that will allow the utilization of waste coal and biomass materials in gasification technologies. Specifically, MTI will obtain samples from co-located sources of biomass and coal waste and perform chemical and physical analysis of selected blends to determine slag flow behavior and interaction with gasifier walls. The team will also use data generated from analysis of feedstock to perform modeling of ash behavior. The overall goal is to improve the ability to manage fluctuations in the properties of coal waste and biomass feedstocks, leading to an increase in hydrogen-producing gasifiers with maximized availability and efficiency, driving down the cost of delivered hydrogen. MTI will work with Gas Technology Institute (GTI) and Wabash Valley Resources to develop advanced gasification technologies that are efficient, economical, and environmentally friendly.

Benefits

- The utilization of coal waste as a feedstock provides economic opportunities for communities affected by the downturn of the coal industry. The feedstock properties management tool proposed by MTI is expected to find use in managing feedstock properties utilizing coal waste resources in priority energy communities such as southern Indiana and the Appalachian regions of West Virginia, Kentucky, Ohio, and Virginia. Additionally, enabling low-cost, sustainable, reliable hydrogen production from waste coal/biomass feedstock blends will support efforts to reduce greenhouse gas emission and reach a net-zero emissions economy.

Recent Results

- Project awarded August 2022. No results reported

QUICK FACTS

AWARD NUMBER:
SC0022871

PROJECT BUDGET

DOE Share:
$250k

Total Award Value:
$250k

CONTACTS

HQ PROJECT MANAGER:
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David Stadem

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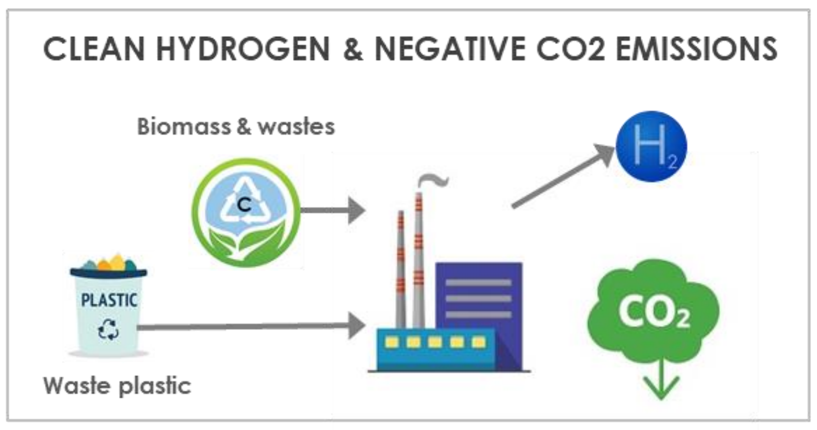
MICROBEAM TECHNOLOGIES, INC.



Modular Hydrogen Separation System for Biomass Gasification

Development of a modular hydrogen separation process for syngas generated by the gasification of coal fines and biomass, producing clean hydrogen with negative carbon emissions

Overview

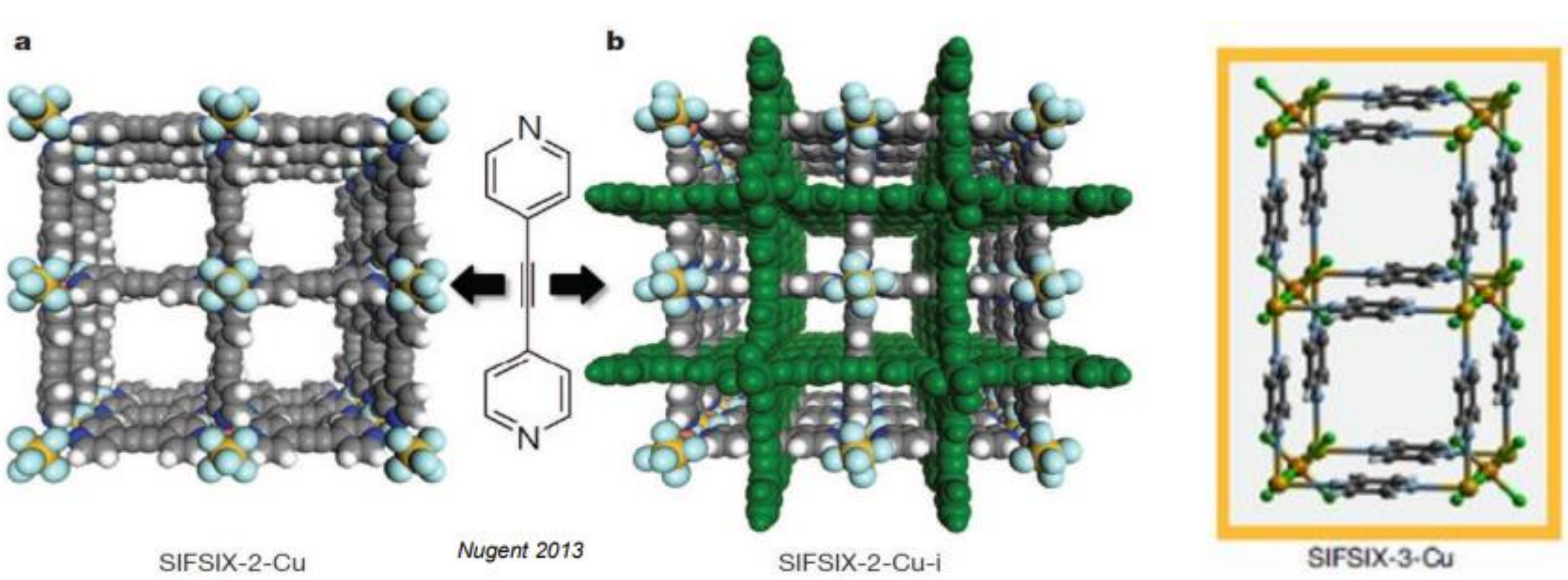
With the current move toward a net-zero carbon economy, clean hydrogen production from gasification of inexpensive carbonaceous feed stocks such as coal wastes and biomass with carbon capture will have an increasing role to play. Combined use of the underutilized feedstocks such as coal fines and biomass, in modular gasification-based processes integrated with hydrogen production and carbon capture, will enable a net-zero or net-negative carbon footprint. However, such modular gasification processes will require the hydrogen separation processes to operate with high efficiency and at lower operating pressures than are typically used in traditional steam methane reforming processes. TDA Research, Inc. proposes to develop a highly efficient modular hydrogen separation process that can efficiently separate the carbon from the hydrogen in the synthesis gas generated by the gasification of coal fines and biomass to produce hydrogen that has negative carbon emissions. TDA's proposed process uses next generation adsorbents to remove carbon dioxide and carbon monoxide (which can be sent for storage or utilization) to produce the high purity hydrogen in a modular pressure swing adsorption (PSA) process.

Benefits

There is a large commercial market for the hydrogen PSA processes, and the CO_2 and CO sorbents developed here for use in clean hydrogen production with a negative carbon footprint from coal waste/biomass gasification and steam methane reforming plants will find both immediate use in today's hydrogen plants and in tomorrow's more environmentally friendly waste and biomass-fueled plants.

Recent Results

- Project awarded August 2022. No results reported



QUICK FACTS

AWARD NUMBER:
SC0022877

PROJECT BUDGET

DOE Share:
$250k

Total Award Value:
$250k

CONTACTS

HQ PROJECT MANAGER:
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TDA RESEARCH