

Techverse, Inc.

Advancing Energy Technologies

www.techverseinc.com





OUR MISSION

Techverse, Inc. is a contract research and development firm in advanced energy generation and utilization concepts with a focus on improving energy efficiency of processes. Techverse develops and utilizes specialized membrane separation processes to suit applications and offers process development through laboratory/bench, pilot, and full scale experimental studies for process and energy efficiency improvements. The company provides consulting services in process development and conducts process model simulations based on fundamental principles for both government agencies and private industrial companies.

COMPANY VALUES

Renewable and sustainable energy supply, environmental responsibility, and energy efficiency are common features in projects we seek. We provide technical excellence, accuracy, due diligence, work ethics, honesty, and accountability in all contract services we provide.

PRIMARY GOALS

Techverse recognizes that with diminishing supply of petroleum-based fuels, it is imperative to develop alternative renewable energy sources for a sustainable future. Increasing concerns over global climate change makes it also necessary to use conventional fossil fuel based power generation in an environmentally responsible manner. Techverse Inc. is therefore actively involved in developing and marketing technologies to reduce cost of renewable biofuels as well as utilization of energy resources in sustainable and energy efficient ways.



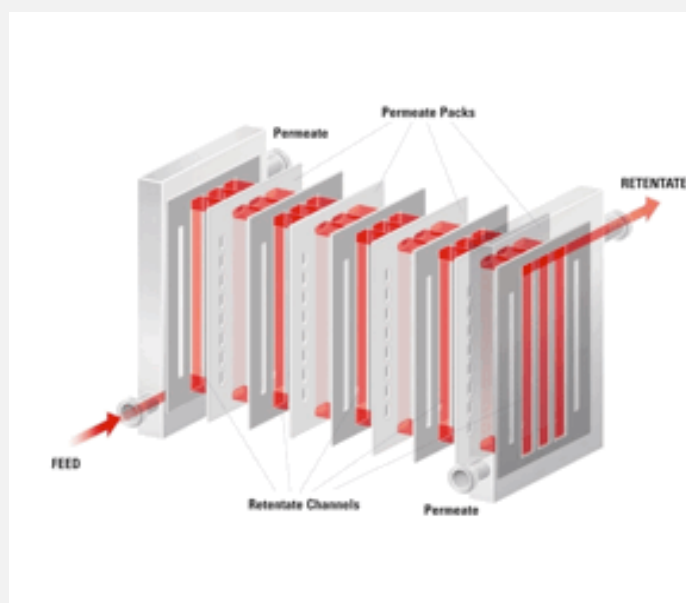
CORE COMPETENCIES

Our scientists have a thorough understanding of basic principles of chemical engineering, chemistry and materials, including transport phenomena and reaction kinetics. Our in-depth technical knowledge and expertise spans advanced energy concepts/technologies including hydrogen and fuel cells, biofuels, gasification, carbon capture, environmental aspects, and membrane separation technologies. We approach our research with innovative process development as well as evaluation of alternative technologies. We use experimental design and planning to develop a detailed understanding of processes for process improvement, problem solving, and scale-up. Our process and equipment models and simulations for diverse processes are developed using fundamental chemical engineering and transport phenomena principles.

OUR TECHNOLOGY

Techverse has experience and expertise in a wide variety of membrane separation technologies both polymeric and inorganic. Techverse has the ability to develop and adapt specialized membrane technologies as needed to suit applications and has been involved in a variety of novel membrane separation techniques and their application for improving energy efficiency. Available technologies include, polymeric and inorganic membranes for micro-, ultra-, and nano-filtration of fluids in chemical, pharmaceutical, and biofuel industries; polymeric and zeolite membranes for gas and vapor separations; facilitated transport liquid membranes utilizing microporous media; and high temperature inorganic Pd-alloy composite membrane for hydrogen separation. Techverse has also integrated membrane separations with chemical reactions for energy efficient membrane reactor applications with process intensification.

Especially for liquid filtration applications, Techverse utilizes SmartFlow Technologies' patented "open channel" membrane module technology as illustrated below. It provides a uniform flow pattern throughout the membrane module utilizing 100% of the membrane surface area. There is equal fluid path length in all flow channels with equal flow resistance avoiding channeling and dead spots with uniform flow velocity over all the membrane surfaces. This module design is especially suitable for handling fluids with high solids content and high viscosity and can provide high fluid recovery as well as high solids concentration than possible with conventional format membrane modules such as spiral wound and hollow fiber modules.



CORE ADVANTAGE

Our customers are able to take advantage of the experience and expertise Techverse offers in a wide range of membrane technologies. Our commitment to finding energy efficient solutions for our customers is a clear advantage to solving problems. Our customers find that our ability to conduct thorough unbiased evaluation of available options for selecting the most cost effective and energy efficient solution results in a successful solution. Our experimental design and planning results in the development of a detailed understanding for process improvement, problem solving, and scale-up for our customers. In addition to our own expertise, we bring to bear a large pool of partners and collaborators when needed to access technologies, resources and facilities to assure successful completion of all our customers' contracted projects. You can rest assured that we are providing technical excellence, accuracy, due diligence, work ethics, honesty, and accountability in the contract services we provide to you.

CONTRACT **R&D**

Techverse has been involved in various research and development projects funded by federal agencies (e.g. U.S. Department of Energy) and private clients to develop membrane technologies for process and energy efficiency improvements. Some examples are discussed below:

- » Algae dewatering - Because of very dilute algae concentrations and consequently very large volumes of water that must be processed, harvesting and concentrating algae contributes a significant cost to algal products. Reduction of capital and operating costs of algae harvesting and concentration step is essential to make algal products economical. Techverse, Inc. has developed a membrane filtration-based, continuous, algae dewatering process to produce algae paste in a U.S. DOE Phase II SBIR project.
- » High temperature H₂ separation - For sustained coal utilization for power generation while addressing possible long-term global climate change, it is imperative to develop cost-effective means to capture and sequester the resulting CO₂. Techverse demonstrated ternary Palladium-alloy based membrane reactor process for pre-combustion CO₂ capture and hydrogen generation in a U.S. DOE Phase I SBIR project. This efficient membrane technology will utilize coal in environmentally responsible IGCC power generation.
- » Water recovery from produced water in oil and gas operations – Water produced in oil and gas production contains high concentration of salts and solids that must be removed for water recycling in cost-effective production operations. In a research project funded by a large oil and gas company, Techverse has demonstrated substantially greater water recovery using SmartFlow membrane modules both in a filtration process as well as in a membrane distillation process compared to that achieved by conventional spiral wound membrane module technology.
- » Biogas upgrading by membrane contactor process – Biogas produced by anaerobic digestion contain substantial amount of acid gases, CO₂ and H₂S, which need to be removed for upgrading of biogas to pipeline quality natural gas. In a research project funded by a private client, Techverse demonstrated efficient use of a membrane contactor process to remove acid gases as well as to regenerate solvent used.



SCOPE OF SERVICES

Techverse provides contract R&D services for process development through laboratory/bench, pilot, and full scale experimental studies for process and energy efficiency improvements as well as through process and equipment model simulations based on fundamental principles.

CUSTOMERS AND MARKETS

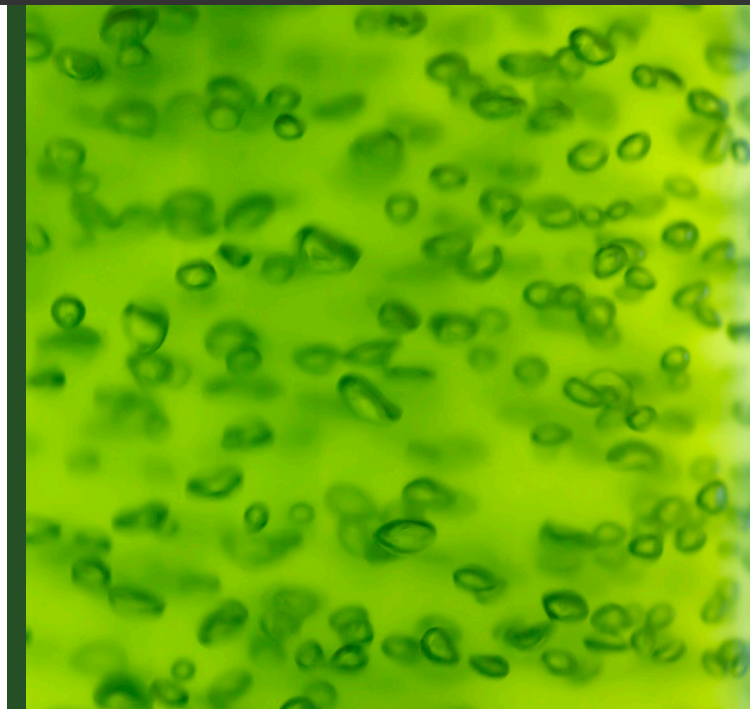
Our customers are entities seeking process and energy efficiency improvements in existing processes or new processes, specifically by using membrane technologies.

Based on our technologies and processes/products, the potential markets are identified as follows:

- » **Algae dewatering** – Organizations involved in algae cultivation, production and harvesting
- » **Water recovery** – Oil and gas companies dealing with produced water
- » **Biogas upgrading** – Organizations involved in anaerobic digestion of wastes and waste treatment and those organizations involved in CO₂ and/or H₂S removal from gas streams
- » **Pd-membrane for hydrogen separation** – Organizations involved in small to large scale hydrogen generation through reforming of hydrocarbons (e.g. methanol) as well as gasification of coal and biomass. Other organizations involved in small scale, possibly portable, hydrogen generation for small PEM fuel cell-based power generators could also find value in this technology.

PARTNERS

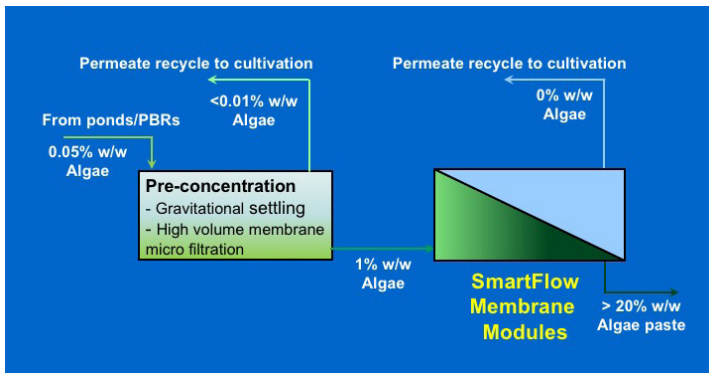
Although Techverse is a small company it has a large pool of partners and collaborators for accessing technologies, resources and facilities as needed to assure successful completion of all our undertakings. Our partners and collaborators include the U.S. Department of Energy and private firms seeking to solve their problems for energy efficiency processes.



RANGE OF PRODUCTS

Based on the status of technologies developed in the contract research and development to date, Techverse can offer algae dewatering processes and water recovery processes at a commercial scale, biogas upgrading process at a pilot scale and Pd-membrane process at a bench/pilot-scale.

- » **Algae Dewatering** – Techverse will design, build and supply a two-stage algae dewatering process of a desired capacity to de-water dilute harvested algae (e.g. $<0.1\%$ w/w) to a high desired concentration (e.g. $>20\%$ w/w) as shown in the schematic below.

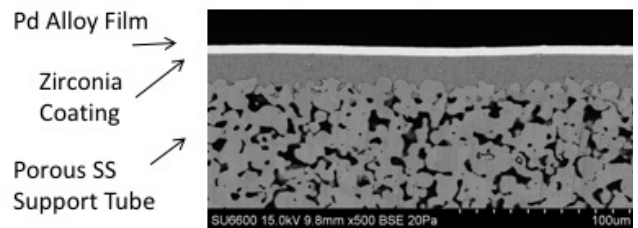


This process has been demonstrated at pilot scale with 100 L/hr feed rate of 1% w/w algae of various strains of industrial interest producing $>20\%$ w/w algae paste in a continuous membrane filtration process. Depending on algae species we will select an appropriate pre-concentration process.

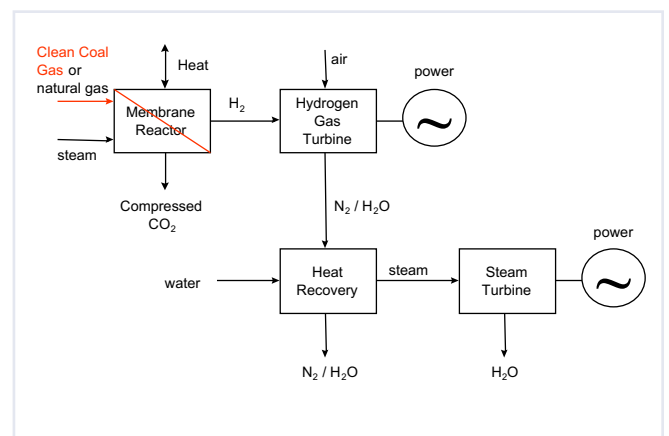
- » **Water recovery from produced water in oil and gas operations** – Like algae dewatering, Techverse will design, build and supply a two-step water recovery process with a first step filtration of the produced water with conventional spiral wound membrane modules to achieve as much water recovery as possible followed by a second step filtration with SmartFlow membrane modules for additional water recovery significantly above the first step limit. Bench-scale testing has demonstrated increasing water recovery from 60% to 85%.

- » **Biogas upgrading by membrane contactor process** - the biogas composition varies significantly, Techverse will conduct pilot scale studies first to obtain relevant mass transfer data to design, build and supply a full-scale system. A regenerable, highly stable absorbent is used in dual loop hydrophobic microporous membrane contactors to achieve efficient acid gas removal and recovery producing pipeline quality natural gas.

- » **High temperature H_2 separation** – Tubular, ternary Pd-alloy membranes, with 2" and 10" active lengths are provided for highly selective, high temperature hydrogen separation from other gases. As shown in the example of a 2" active length membrane, thin Pd-alloy film is deposited on the outer surface of a porous substrate. The welded non-porous stainless-steel tubes at both ends of the membrane tube facilitates their assembly in a single or a multi-tube module.



These membrane tubes have been demonstrated for hydrogen production in a bench-scale integrated water gas shift (WGS) membrane reactor process suitable for a coal-derived synthesis gas environment with nearly complete conversion of carbon monoxide in syngas and high purity hydrogen production. Large scale membrane modules may be fabricated for membrane reactor-based power generation as shown in the schematic process flow diagram.



COMPANY PROFILE

Techverse Inc. began active contract R&D operations in 2008. It leases laboratory and office facilities, as needed, at the First Flight Venture Center, a small business incubator, in Research Triangle Park, in central North Carolina. It also has access to specialty laboratory facilities through its partners and collaborators. Techverse has actively participated in government funding for its research both through the SBIR program and other contract efforts while also maintaining revenue from consulting services and contracts from industrial customers.

The founder and president of Techverse, Inc., Dr. Ashok Damle, has over 30 years of contract research experience working with several U. S. Government agencies and has been successfully involved in “technical marketing” and generating research funding for promising concepts. Dr. Damle also has business development experience in a large Fortune 500 company environment. He understands the value of team work and using appropriate resources and necessary expertise together to provide solutions to the company clients.

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