PROGRAM facts

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Vision 21

07/2001

VISION 21 PROGRAM

"We are building the foundation for a new generation of energy facilities capable of efficiently using our most abundant traditional fuels while virtually eliminating environmental concerns… Vision 21 represents the future of clean energy, and these projects will help us get there faster."

Secretary of Energy Bill Richardson

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VISION 21 WEBSITE

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Vision 21 Project List

Critical Components for Direct Fuel Cell/Turbine Ultra High Efficiency System

The project team will to create a fuel cell/turbine system that provides efficiencies and emissions targets that meet or exceed stringent Vision 21 goals. Specifically, high-utilization fuel cell and system components would be developed. Sub-scale tests of the fuel cell/hybrid system would be performed to yield data for integrating an existing 250-kilowatt fuel cell stack with a commercially available micro-turbine, and a conceptual design of a 40-megawatt Vision 21 ultra-high-efficiency power plant will be prepared. An attractive feature of the proposed system is that it allows the fuel cell and turbine modules to operate at independent pressures and, therefore, enhance system performance. The fuel cell hybrid system has merit as a stand-alone, distributed or central-power-generation unit.

Zero Emissions Power Plants Using Solid Oxide Fuel Cells and Oxygen Transport Membranes

Siemens Westinghouse Power Corporation, in conjunction with Praxair, Inc., will to develop a technology that would create zero-emissions Vision 21 power plants using solid oxide fuel cells (SOFCs) and ceramic oxygen transport membranes. The approach modifies the design of a tubular SOFC module by including an afterburner stack of tubular oxygen transport membranes. Oxygen transported through the membrane would be used to oxidize the SOFCs depleted fuel, converting it into carbon dioxide and steam. The carbon dioxide can then be easily separated for eventual sequestration by condensing the steam.

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Critical Components for Direct Fuel Cell/Turbine Ultra High Efficiency System

Principal Investigator:
Anthony J. Leo, FuelCell Energy, Inc., (203) 825-6057

Partners:
FuelCell Energy Inc., Danbury, Connecticut
Allison Engine Company, Indianapolis, Indiana
Capstone Turbine Corp., Woodland Hills, California

Zero Emissions Power Plants Using Solid Oxide Fuel Cells and Oxygen Transport Membranes

Principal Investigator: Norman Bessette, Siemens Westinghouse Power Corporation, (412) 256-1055

Partners:
Siemens Westinghouse Power Corporation, Pittsburgh, Pennsylvania
Praxair, Tonawanda, New York

Advanced Hydrogen Transport Membranes for Vision 21 Fossil Fuel Plants

Principal Investigator: Anthony F. Sammells, Eltron Research, Inc., (303) 440-8008

Partners:
Eltron Research, Inc., Boulder, Colorado
Coors,
Chevron, Richmond, California
United Catalyst, Lexington, Kentucky
McDermott Technology Inc., Lynchburg, Virginia
Argonne National Laboratory, Chicago, Illinois
Oak Ridge National Laboratory, Oak Ridge, Tennessee

Fabricate and Test an Advanced Non-Polluting Drive Gas Generator

Principal Investigator: Eugene Baxter, Clean Energy Systems, Inc., (916) 925-8206

Clean Energy Systems, Inc., Sacramento, California

Systems Integration Methodology

Principal Investigator:
Scott Samuelson, National Fuel Research Center, (949) 824-1558

Partners:
National Fuel Research Center, Irvine, California
KraftWork Systems Inc., East Hartford, Connecticut
Spencer Management Associates, Reading, Pennsylvania

Advanced Hydrogen Transport Membranes for Vision 21 Fossil Fuel Plants

This project consists of developing an environmentally benign, inexpensive, efficient method of separating hydrogen from coal gasification gas streams by using dense ceramic membranes. These membranes are based, in part, on Eltron-patented materials that have a demonstrated ability for rapid proton and electron conduction. Hydrogen separation is desirable for a *Vision 21* application because the hydrogen can be used in a fuel cell system that achieves very high efficiencies while simultaneously separating carbon dioxide for possible sequestration or chemical applications. The technical challenge is to create materials with enhanced conductivity and stability, and to develop thin ceramic structures that achieve hydrogen-separation rates comparable to those used in industrial processes. The effort includes catalysis, ceramic-processing methods, and high-pressure separation unit design.

Fabricate and Test an Advanced Non-Polluting Drive Gas Generator

Clean Energy Systems will design and test a 10-megawatt high-temperature gas generator to be used in a high-efficiency power plant. Based on a rocket engine design, the generator uses a clean gaseous fuel that is burned with oxygen. With water injected to cool the combustor, a high-temperature, high-pressure gas containing more than 90% water (steam) would be produced. This gas would be fed to an advanced turbine, which needs to be developed and is not part of this project. Engineering challenges include building a device that is able to mix water and oxygen “perfectly,” combine water and combustion products in a precise manner, and design a combustor with long-life operation.

Systems Integration Methodology

NFCRC outline a two-step approach in which two computer software programs — designed to analyze all possible fossil-fuel-based combustion systems applicable to a Vision 21 power plant — eliminate the deficiencies associated with current computer models. In Part I, using two computer programs already successfully applied to DOE’s Advanced Turbine Systems and High Performance Power Systems programs, the proposers would first identify and analyze prospective power cycles with high efficiency and environmental performance. Then temperature, piping, and coding requirements for each technology module to be used in a *Vision 21* plant would be investigated. Effects on power plant operation, including startup, shutdown, part load, transient operation, and emergency response would be considered. Part II would consist of non-technical issues affecting system integration, such as trade-offs between capital and operating costs. In this way, important features that would improve plant operations at the cost of plant efficiency would be explored, identified, and factored into plant designs.

Software Integration for Vision 21 Virtual Demonstration

Fluent will develop interfaces between computer models as a step toward building a full-function Vision 21 plant design. This effort involves creating an integrated software system capable of linking hierarchy models to allow seamless integration of flow-sheet models with more detailed Computational Fluid Dynamics (CFD) codes so that more efficient Vision 21 systems may be designed. When completed, the proposed system would link a set of defined spreadsheet codes with CFD models. The project team would use and extend existing computer codes, increasing the acceptance of its work.

Development of Oxide Dispersion Strengthened Alloys (ODS) *Heat Exchanger Tubing*

Huntington Alloys will develop heat exchanger tubing made of oxide dispersion strengthened alloys (ODS) with enough circumferential creep strength — lacking in commercial ODS tubing — for long-term use as heat exchanger tubing in very high-temperature applications. The proposers also plan to produce adequate connecting joints for the tubing, establish bending strain limits, establish high temperature corrosion limits and generate data for heat exchanger designers to use.

Development of Pressurized Circulating Fluidized Bed Partial Gasification Module

Foster Wheeler will develop a pressurized circulating fluidized bed partial gasification module (PGM). The Foster Wheeler advocates using the partial gasification module because it offers all the advantages of gasifying fossil fuels, while providing significant fuel flexibility and the ability to accommodate the most advanced steam turbines and gas turbines. The PMG carbon conversion can be adjusted to achieve optimal thermal efficiency with the particular configuration. PGM-based Vision 21 plants would be able to generate electric power from coal at thermal efficiencies over 60% and meet all the stringent environmental requirements.

Novel Composite Membranes for Hydrogen Separation in Gasification Processes in Vision 21 Energy Plants

ITN Energy Systems has a novel approach to hydrogen separation membrane technology where fundamental engineering material development is fully integrated into fabrication designs, combining functionally graded materials, monolithic module concept and plasma spray manufacturing techniques. The technology is based on the use of Ion Conducting Ceramic Membranes (ICCM) for the selective transport of hydrogen. The membranes will consist of composites of a proton conducting ceramic and a second metallic phase to promote electrical conductivity. ITN Energy Systems will develop and evaluate composite membranes and catalysts for hydrogen separation. Components of the monolithic modules will be fabricated by plasma spray processing. The proposed technology also results in a stream of pure carbon dioxide. This allows for easy sequestration or other use of this greenhouse gas.

Fuel-Flexible Gasification-Combustion Technology for Production of Hydrogen and Sequestration-Ready CO_2

GE-Energy and Environmental Research has developed an innovative fuel-flexible advanced gasification-combustion (AGC) concept to produce hydrogen for fuel cells or combustion turbines, and a separate stream of sequestration-ready CO_2. In the AGC technology, coal/opportunity fuels and air are simultaneously converted into separate streams of (1) pure hydrogen to be utilized in fuel cells, (2) sequestration-ready CO_2, and (3) high-temperature/pressure oxygen depleted air (i.e., nearly pure nitrogen) to produce electricity in a gas turbine. The process produces near-zero emissions and has a theoretical thermal efficiency up to 93% based on the heating value of the fuel.

Software Integration for Vision 21 Virtual Demonstration

Principal Investigator: Dr. Madhava Syamlal, Fluent Inc., (603) 643-2600

Partners:

Fluent Inc., Lebanon, New Hampshire,

ABB Alstom Power, Windsor, Connecticut

Aspen Technology,

Intergraph,

West Virginia University, Morgantown, West Virginia

Development of Oxide Dispersion Strengthened (ODS) Alloys Heat Exchanger Tubing

Principal Investigator: Mark A. Harper, Huntington Alloys, (304) 526-5057

Partners:

Huntington Alloys, Huntington, West Virginia

Foster Wheeler Development Corp., Livingston, New Jersey;

Oak Ridge National Laboratory, Oak Ridge, Tennessee;

University of California at San Diego, San Diego, California;

Michigan Technological University; Houghton, Michigan;

Edison Welding Institute, Columbus, Ohio

Development of Pressurized Circulating Fluidized Bed Partial Gasification Module

Principal Investigator: Archie Robertson, Foster Wheeler Development Corp., (973) 535-2328

Partners:

Foster Wheeler Development Corporation, Livingston, New Jersey,

Nexant, San Francisco, California

Praxair, Danbury, Connecticut

Reaction Engineering International, Salt Lake City, Utah

Corning, Elmira, New York

ADA Technology, Livermore, California

Novel Composite Membranes for Hydrogen Separation in Gasification Processes in Vision 21 Energy Plants

Principal Investigator: Michael Schwartz, ITN Energy Systems, Inc., (303) 285-5118

Partners:

ITN Energy Systems, Inc., Wheat Ridge, Colorado

Idaho National Engineering Environmental Laboratory, Idaho Falls, Idaho

Nexant, San Francisco, California

Argonne National Laboratory, Argonne, Illinois

Praxair, Inc., Danbury, Connecticut

Fuel-Flexible Gasification Combustion Technology for Production of Hydrogen and Sequestration-Ready CO_2

Principal Investigator:
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GE Energy and Environmental Research Corp., Irvine, California

A Computational Workbench Environment for Virtual Power Plant Simulation

Principal Investigator:
Michael J. Bockelie,
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Partners:

Reaction Engineering International, Salt Lake City, Utah

Visual Influence, Sandy, Utah

RECOM, Magstad, Germany

Foster Wheeler Development Corp., Livingston, New Jersey

Massachusetts Institute of Technology, Cambridge, Massachusetts

Iowa State University, Ames, Iowa

Low Emission Simulation Software for the Design of Low Emission Combustion Systems for Vision 21 Plants

Principal Investigator:
Clifford E. Smith, CFD Research Corp.,
(256) 726-4813

Partners:

CFD Research Corp., Huntsville, Alabama

UC-Berkeley, Berkeley, California

Georgia Institute of Technology, Atlanta, Georgia

State University of New York (SUNY) Buffalo, Buffalo, New York

Siemens Westinghouse, Orlando, Florida

Pratt & Whitney, East Hartford, Connecticut

GE, Irving, California

Solar Turbine, San Diego, California

Allied Signal, Phoenix, Arizona

Coen Co., Burlingame, California

MTI Technologies, Anaheim, California

Vapor Power Group, Niles, Illinois

Coarse-grid Simulation of Reacting and Non-reacting Gas-Particle Flows

Principal Investigator:
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A Computational Workbench Environment for Virtual Power Plant Simulation

Reaction Engineering International will develop and demonstrate a computational workbench for simulating the performance and emissions of a *Vision 21* power plant. The workbench will be constructed as a tightly integrated problem solving environment that contains an array of tools and models that communicate in a seamless manner. It will be designed for the non-specialist and will include models ranging in complexity from heat/mass/energy balance reactor models to detailed Computational Fluid Dynamics (CFD) based models. The project team will develop models for transient and steady state simulations of key energy plant components, including boilers, fluidized beds, gasifiers, combustors, fuel cells and clean-up process components.

Low Emission Simulation Software for the Design of Low Emission Combustion Systems for Vision 21 Plants

The CFD Research Corporation will develop an advanced computational software tool to design low emission combustion systems for gas turbines. The proposed simulation tool will greatly reduce the number of experimental tests. In addition, the Large Eddy Simulation software will provide the capability of assessing and adapting low-emission combustors to alternate fuels, and will greatly reduce the development time cycle of combustion systems. This revolutionary combustion simulation software will be able to accurately simulate the highly transient nature of gaseous-fueled (e.g., natural gas, low-Btu syngas, hydrogen, biogas, etc.) turbulent combustion and assess innovative concepts needed for Vision 21 plants.

Coarse-grid Simulation of Reacting and Non-reacting Gas-Particle Flows

Many processes involved in coal utilization involve handling of fine particles, their pneumatic transport, and their reactions in fluidized beds, spouted beds and circulating fluidized beds. One of the factors limiting our ability to simulate these processes is the hydrodynamics encountered in them. Two major issues that contribute to this limitation are lack of good and computationally expedient models for frictional interaction between particles, and models to capture the consequences of meso-scale structures that are ubiquitous in gas-solid flows. Princeton University's will use a combination of computer simulations and experiments to develop and validate these models. Princeton University also plans to implement and validate these models using MFIX, which is a virtual demonstration tool developed at DOE's National Energy Technology Laboratory (NETL).