

SHELL CENTER
FOR SUSTAINABILITY

YEAR END REPORT 2003

Environmental & Energy Systems Institute
Rice University





The goal of sustainable development is to maximize the net benefits of economic growth while preserving and improving the quality of our environment to be enjoyed by future generations. This is a difficult task, especially in poorer nations that will require better research, education and

outreach than is available today. Rice University has addressed these needs by launching the Shell Center for Sustainability in 2003 with generous support initially from the Shell Oil Company Foundation and subsequently from Shell Oil Company.

The Shell Center builds on Rice's unique interdisciplinary traditions in teaching and research and focuses on five critical research areas:

- Energy resources, carbon cycle and air quality
- Biodiversity
- Water
- Health
- Role of the private sector in sustainability

The Center's outreach activities this first year have included a highly regarded seminar series on air quality attracting more than 500 participants from business, government, NGO and academia sectors. Educational efforts have focused on developing new approaches to sustainable development education at the high school, undergraduate, graduate and corporate education levels.

In launching these initiatives, the Center has forged effective working relationships with Rice faculty and students as well as with public and private institutions, and established a foundation that in coming years will enable Rice to make important contributions toward improving private and public policies and practices for sustainable development.

Dr. Malcolm Gillis
President
Rice University

Mission and Objectives of the Shell Center for Sustainability

Rice University and the Shell Oil Company Foundation jointly launched the Shell Center for Sustainability in 2003. Supplemental funding has been provided by the Shell Oil Company. The Center is affiliated with Rice's Environmental & Energy Systems Institute and is directed by Christian R. Holmes.

The Center's mission is to create an interdisciplinary program of education, research, and outreach to foster sustainability. The Center draws upon the various strengths of the university and collaborates with other highly respected regional, U.S. and global institutions of higher learning as well as nongovernmental organizations (NGOs). In so doing, it seeks to be a hub for collaboration among experts dealing with societal, environmental and financial issues arising from economic activities.

The Objectives of the Shell Center

Create new technologies, processes, products and market mechanisms that will advance sustainable economic growth and help build a sound public infrastructure.

Develop new tools in engineering, the social sciences and the natural sciences that enhance the understanding of requirements for sustainability.

Help remove institutional barriers to sensible environmental and social practices and contribute to new policy instruments for achieving sustainability.

Provide society with broadly educated environmental, technical and natural resource experts to mold future decision-making in the private and public sectors to help assure a more sustainable future in both developed and developing nations.

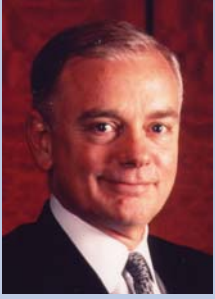
Enhance the exchange of information in the public and private sectors by serving as an independent forum for open discussion and constructive dialogue on sustainable development issues and policies across a broad spectrum of stakeholders including U.S. and international business leaders, academia, NGOs and senior policy makers.

Research issues posed by environmental and societal impacts arising from economic activities.

Develop new engineering and scientific curricula to educate a new generation of scientists who will incorporate sustainability concepts into business plans, designs and processes.

Advance thinking around market-based mechanisms that can be deployed to enhance sustainability.

Develop linkages with other institutions and non-governmental organizations at local, regional, national and international levels.



Our mission at the Shell Center is to enhance the ability of mankind to sustain its environment, society and economy in this and future generations. In so doing, we are interested not only in how the private sector can best foster sustainability, but how public sector policy reform can promote the sustainable use of resources.

Our programs address such key questions as: How can we provide the energy and water needed to sustain a 50 percent increase in human population without irreparably damaging our environment? How do we shift from carbon-based energy sources to non-carbon-based forms of energy, and as we shift, how do we meet our energy needs from traditional carbon-based sources in a more sustainable fashion? How do we better understand, communicate and respond not only to the environmental impacts, but also to the health impacts, of industrialization? How can citizens have a more active role in their "stake" in economic development?

This report describes how the Center, supported by Rice's faculty, staff and students, is responding to these and other critical questions through its research, education and outreach programs.

We are a new Center - launched in early 2003 - with the expectation that we can make a difference. We are confident that we can do so due to the quality and commitment of Rice's faculty, staff and students. In addition, we are developing fruitful collaborative relationships with public and private sector entities.

We hope this report will both educate others on our work and interest individuals and organizations from the public and private sectors to join with us in our efforts to meet the critical challenges of fostering global sustainability.

Christian Holmes
Executive Director
Shell Center for Sustainability

Research, Outreach and Education Supported by the Shell Center

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Research

The Shell Center for Sustainability committed funds to support several initial research projects in the fall of 2003. Work on these projects will begin in 2004 and continue into 2005. Primarily, Rice faculty, staff and students conduct the research.

Center research falls into five areas:

- Energy resources, carbon cycle and air quality
- Water
- Biodiversity
- Role of the private sector in fostering sustainability and stakeholder relationships
- Health

GAS HYDRATES

Gas Hydrates: Climate Change and Energy Supply
Dr. Gerald Roy Dickens, Dr. Walter Chapman,
Dr. George J. Hirasaki, Dr. Manik Talwani

Gas hydrates are crystalline solids composed of gas molecules trapped inside a rigid lattice of water molecules. These compounds occur naturally in Arctic permafrost at depths greater than 200 meters, and they also form in marine sediments at ocean floor depths greater than 500 meters where temperatures hover near freezing.

Gas Hydrates offer a vast, untapped source of energy, a key element in the global carbon balance and past global warming events and the number one problem for hydrocarbon transmission in deepwater oil and gas production. This research will combine Rice and external expertise in the natural occurrence of methane hydrates, thermodynamics and kinetics of gas hydrates, and transport through porous media. The research will develop mechanistic models to describe the accumulation and dissociation of gas hydrates with regard to climate change and energy exploration and production. It also will support seminars to address both global climate and sustainable energy production, investigate the contribution of gas hydrates to global climate change and future energy supplies. These seminars will bring together researchers at Rice, University of Houston, Texas Tech University and local companies. Shell Center funds will enable the research team to enlist a graduate student's assistance in modeling the dynamics of the accumulation and dissociation of methane hydrates in deep ocean sediments.

CARBON SEQUESTRATION

Carbon Capture and Sequestration
Dr. Ron Sass, Dr. Neal F. Lane, Dr. Robert Harris

A growing concern among scientists and others is that higher concentrations of greenhouse gases (GHGs) will result in unpredictable and potentially dangerous changes in the Earth's climate.

This project will fund a major workshop that will explore various environmentally favorable and economically sound ways to control and reduce atmospheric greenhouse gases through an integrated set of Houston-area demonstration projects for carbon capture and sequestration. The workshop will contribute to forming a research agenda.

Because of the concentration of industrial and academic talent in the energy sector, Houston has the potential to become a global leader in developing, demonstrating and carrying out technologically, environmentally and financially sound methods for reductions in greenhouse gas emissions. The workshop is a first step toward developing carbon reduction and demonstration projects, including the possible creation of a FutureGen power generation pilot plant that can establish Houston at the forefront of such development.

Shell Center funds will enable the research team to organize and convene the workshop at Rice University to discuss the parameters for building a private/public partnership to implement a pilot project in Houston. Shell Center and the James A. Baker III Institute for Public Policy will fund the workshop.

NANOTECHNOLOGY AND ENERGY

Nanotechnology and Energy

Dr. Rick Smalley, Dr. Neal F. Lane, Wade Adams, Amy Myers Jaffe, Dr. Robert H. Hauge, Dr. Dagobert Brito, Dr. Peter R. Hartley, Dr. Steven C. Currall

Advancement of nanotechnology solutions can be an integral component in meeting global energy challenges. This project will support three joint seminars — sponsored by the Shell Center, the Environmental & Energy Systems Institute, the Center for Nanoscale Science Technology and the Baker Institute for Public Policy — that will investigate the potential for nanoscience to contribute to funding breakthrough solutions.

The first seminar will investigate the potential for nanoscience to contribute to solar energy. The second seminar will investigate the potential for nanoscience to contribute to enhancing electricity transmission grids, transportation and storage. The third seminar will investigate hydrogen storage problems and possible solutions that nanoscience can offer.

OZONE RESEARCH

Dr. Gary Morris, Dr. Matthew Fraser

This project establishes an ozone-monitoring program at Rice University with the goal of developing a better understanding of tropospheric ozone pollution. The project will acquire and establish a station from which to launch balloons (Ozonesondes) with payloads designed to acquire in situ profiles of ozone pollution.

Although ozone pollution is a significant problem in Houston, the Houston area has no established program to monitor ozone concentrations at any altitude in the atmosphere but at the surface. By measuring the vertical distribution of ozone as a function of time, we will be able to establish clearly the nature (local vs. transported), and extent and origins (industrial activity versus mobile sources) of local ozone, thus providing an important step to finding solutions. The establishment of regular profile measurements in Houston is an essential step to assessing issues of sustainability.

WATER: MEMBRANE TECHNOLOGIES

Dr. Mark Wiesner, Dr. Andrew R. Barron, Dr. Michael Wong, Dr. Matteo Pasquali, Dr. Vicki L. Colvin

This project brings together expertise from several Rice departments in the area of membrane fabrication and use to examine applications where membrane science is likely to enable game-changing innovations in water management and energy production. Leveraging expertise in membrane processes, water treatment, catalysis and nanochemistry, this team addresses priorities in the areas of desalination, water supply in remote or developing areas and managing produced waters and brines in energy production.

Fundamental research addresses the development of new materials and processes, specifically in the areas of reactive membranes, nanostructured membranes, membranes for proton transfer in fuel cells and gas separation membranes.

BIODIVERSITY-FORESTRY

Invasive Species Control in Floodplain Forests

Dr. William Edward Rogers, Dr. Evan H. Siemann, Dr. Dale S. Sawyer

The Chinese Tallow Tree (*Sapium sebiferum*) invades many habitats throughout the Texas Gulf Coast and southeastern United States. In the absence of an effective management strategy, this non-native tree will likely continue to displace the native flora and fauna, resulting in biologically impoverished, economically degraded woodlands.

This project will address the effects of removing an invasive plant in native plant and animal communities.

BIOLINGUISTIC DIVERSITY

Dr. Matt Shibatani, Dr. Gail M. Coelho, Dr. Stephen Tyler

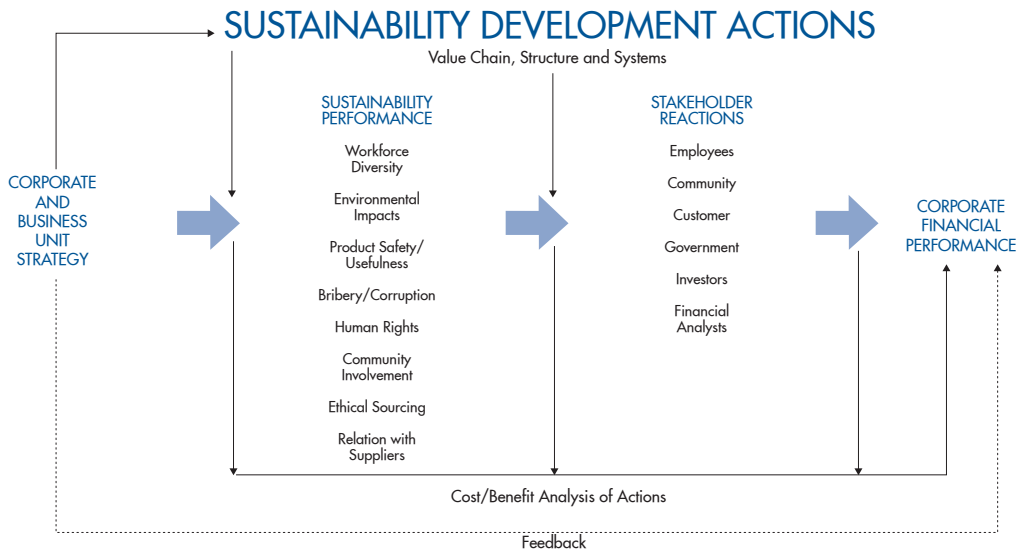
There is accumulating evidence that biodiversity and linguistic diversity go hand-in-hand, and that one cannot be studied separately from the other. Where there is the greatest biodiversity, the highest linguistic diversity tends to be found, e.g. New Guinea.

This project analyzes the relationship between language and the traditional ecological knowledge it encodes. The goal of this project is to gain an understanding of the role of language in the maintenance of symbiotic human-environment relationships, the role of language in the acquisition, accumulation, maintenance, and transmission of

traditional ecological knowledge and the way language loss affects these processes.

Research will be carried out in the Nilgiri Mountains of southern India, an area rich in biological as well as linguistic diversity. Shell Center funds will enable the research team to work with members of the Betta Kurumba community, an ethnic group who lives in the montane tropical forests of Nilgiris. The research team will document the language and lifestyle of the group through audio recordings of oral narratives in the native language and video recordings of community activities and gather information about the group's utilization of natural resources and their traditional methods of resource management.

The Role of the Private Sector in Sustainability



Drivers of Sustainability Model Source: Epstein and Roy (2000)

BUSINESS CASE FOR SUSTAINABLE DEVELOPMENT

Dr. Marc J. Epstein

This project concentrates on the need of companies to integrate social and environmental impacts into management decision-making. The measurement and reporting of social and environmental impacts is key to corporate accountability.

The project will develop the tools and techniques to evaluate affects of company products, processes and activities on both the company and on society and provide for a more complete analysis of all capital and operational investments. By ignoring the future social and environmental impacts, company capital resources allocation decisions are flawed. The project will also examine company operational and

capital investment decisions and the impact of these investments on financial performance through both earning and share price.

STAKEHOLDER RELATIONS

Dr. Claire Auplat

Increasingly, a wide range of organizations, generally known as non-governmental organizations (NGOs), play critical roles in the sustainable development process. These include non-governmental, voluntary, non-profit or third-sector organizations, foundations and social enterprises. This research will examine best-in-class business processes in the energy sector and non-governmental organizations.

HEALTH IMPACT ASSESSMENT

Dr. Alvin R. Tarlov, Ms. Kathryn Elizabeth Higgins

For many people, the word sustainability brings to mind concern about forestry, air quality, natural resources and wildlife. A very important area of sustainability that is often overlooked, however, is health. Not only must the environment itself be sustained, but the quality of life of the people inhabiting that environment also must be carefully examined and protected. Many safeguards, such as the environmental impact statement (EIS), are now in place in the United States to ensure the review of most projects that potentially could have a negative effect on the environment.

Over the last three decades, EISs have grown to be almost exclusively environmental in scope and thus do not take social or health impacts into account when assessing a project, program or policy. The oversight has been pointed out by many policy and public health researchers who have created completely separate tools — social impact assessment (SIA) and health impact assessment — to address these needs. The Shell Center will support the efforts of a Rice University based initiative, the Texas Program for Society and Health (TPSH), to research the potential of HIA in public policy development to improve population health.

Outreach

The Center conducts an active outreach program seeking to engage the public, representatives from business, government, non-governmental organizations and academia on critical sustainability issues.

SHELL CENTER INAUGURAL CONFERENCE

Shell Center's first outreach activity was its inaugural conference, which addressed opportunities to promote innovative solutions to such global needs as energy supply, environmental protection, provision of water and clean air, and economic development in developed and developing countries. Speakers and participants considered the social, economic and environmental implications of their observations and recommendations, as well as the role of technology, the private sector and private/public partnerships in fostering sustainability. Text and video presentations from the conference may be found at www.ruf.rice.edu/~eesi/scs/

Conference Speakers

Global Perspectives- Sustainability and Development

Dr. Malcolm Gillis, President, Rice University

Sir Philip Watts, Chairman of the Committee of Managing Directors, The Royal Dutch/Shell Group

Dr. Paula Dobriansky, U.S. Under Secretary of State for Global Affairs

Mr. Guy Hascoet, Former French Minister of State for Social Economy

Mr. Christian Holmes, Executive Director, Shell Center for Sustainability and Environmental and Energy Systems Institute

Dr. Richard Sandor, Chairman and CEO, Environmental Financial Products, LLC

Mr. Bjorn Stigson, President, World Council for Sustainable Development

Mr. Hiroyuki Watanabe, Senior Managing Director, Toyota Motor Corporation

Biodiversity Challenges

Dr. Francisco Dallmeier, Director, Monitoring and Assessment of Biodiversity Program; National Zoological Park Conservation and Research Center Smithsonian Institute

Mr. James Blackburn, Chair, Galveston Bay Conservation and Preservation Association

Lessons Learned

Market Based Solutions and Public Private Partnerships

Air

Dr. Matthew Fraser, Assistant Professor, Civil and Environmental Engineering

Mr. Hank Habicht, Chief Executive, Global Environment Technology Foundation

Energy

Mr. Kurt Hoffman, Director, Shell Foundation

Dr. David G. Victor, Director, Stanford University Program on Energy and Sustainable Development

Water

Dr. Mark R. Wiesner, Director, Environmental and Energy Systems Institute, Rice University

Mr. Alain Dangeard, Chairman and CEO, M.E.E. Development

Mr. James Blackburn, Chair, Galveston Bay Conservation and Preservation Association

AIR QUALITY SEMINARS

The Shell Center air quality seminars are an extension of the findings of the air quality and urban sustainability workshop held during the Shell Center's Inaugural Conference in March 2003. At that conference, participants expressed their desire for more systematic and comprehensive sharing of information related to air quality with the Houston community.

The Center subsequently conducted a series of four seminars on Houston air quality, focusing on regulations, air monitoring, air modeling and health effects. Some 500 participants from the business, government, NGO and academic sectors attended the seminars.

The seminars examined four key questions:

Regulations: How will current regulations be revised to improve air quality?

Modeling: How well do air quality models simulate air pollution emissions and the corresponding reductions needed to protect health and the environment?

Air Monitoring: What regional strategies for meeting ozone standards do we need in Houston?

Health: What are the health problems caused or exacerbated by Houston's air pollution?

Discussion focused on the challenges faced by emissions from the Houston Ship Channel Petrochemical Complex and the related reduction and reporting of "fugitive emissions;" the need for epidemiological studies related to diseases such as asthma; the challenges faced in developing models upon which to base air regulations and the implementation of the clean air regulations within the State Implementation Plan (SIP). Text and video presentations from the conference may be found at www.ruf.rice.edu/~eesi/scs/

Air Monitoring

Speaker

Dr. Peter Daum, Head, Atmospheric Sciences Department of Environmental Sciences, Brookhaven National Laboratory

Panelists

Mr. Walter Crow, URS

Dr. Dave Sullivan, Texas Commission on Environmental Quality

Dr. Matthew Fraser, Rice University

Mr. John Wilson, Galveston-Houston Association for Smog Prevention

Regulations

Speaker

Mr. Randy Wood, Deputy Director, Environmental Policy Analysis, Texas Commission on Environmental Quality

Panelists

Mr. Jim Blackburn, Blackburn & Associates

Mr. Ed Feith, Reliant Energy

Mr. David Crossley, Gulf Coast Institute

Mr. David Hitchcock, Houston Advanced Research Center

Modeling

Speaker

Dr. Harvey Jeffries, Professor, Environmental Sciences and Engineering University of North Carolina

Panelists

Mr. Al Hendler, URS

Dr. Katherine Ensor, Chair, Statistics Department, Rice University

Dr. Ramon Alvarez, Environmental Defense

Dr. Daewon Byun, Atmospheric Sciences Department, University of Houston

Mr. Chuck Mueller, Texas Commission on Environmental Quality

Health Effects

Speaker

Dr. Winifred J. Hamilton, Director, Environmental Health, Chronic Disease Prevention & Control Research Center, Baylor College of Medicine

Panelists

Dr. Robert Biles, ExxonMobil

Dr. Alvin Tarlov, Baker Institute for Public Policy

Ms. Jane J. Laping, Mothers for Clean Air

Dr. Stuart Abramson, Baylor College of Medicine

FIRE & ICE SEMINAR

Theory has it that more energy resides in gas hydrates than in conventional resources of existing oil and coal deposits. The Shell Center for Sustainability, the James A. Baker III Institute for Public Policy and Rice University's Environmental & Energy Systems Institute sponsored "Fire & Ice: Implications for Energy Development and the Carbon Cycle" — a workshop that focused on the important subject of gas hydrates.

Gas hydrates may represent a key component in the global carbon cycle and climate change. Thus, the goal of the workshop was to identify and discuss the key research challenges for gas hydrates in the areas of global climate change, exploration and production of gas hydrates as an energy resource, transportation of hydrocarbons and seafloor stability.

The workshop investigated the benefits of studying hydrates through an integrated approach that joins existing knowledge, methods and data from many academic disciplines, including geology, oceanography, engineering and biology.

Global Carbon Cycle and Climate Change

Session Chair: **Dr. Gerald Dickens**, Rice University

Interdisciplinary Research on Gas Hydrates and Climate Change

Dr. Gerald Dickens, Rice University

Overview on How Gas Hydrates Form in Nature

Dr. George Claypool

Methane Production and Consumption in Marine Sediments

Dr. David Valentine, University of California, Santa Barbara

Exploration and Production: First Efforts and Technical Issues

Session Chair: **Dr. George Hirasaki**, Rice University

Production Scenarios

Dr. Arthur Johnson, Hydrate Energy International

Assessment of the Resource Potential of Methane Hydrate in the Nankai Trough, Offshore Central Japan

Dr. Yoshihiro Tsuji, Japan National Oil Corporation

Resource Potential in the Gulf of Mexico and the North Slope of Alaska

Dr. Alexei Milkov, BP

Flow Assurance

Dr. Ajay Mehta, Shell

Production Challenges & Kinetics

Session Chair: **Dr. Walter Chapman**, Rice University

Gas Production from Hydrates under Various Geologic Conditions

Dr. G.J. Moridis, Lawrence Berkeley National Laboratory

Kinetics

Dr. Raj Bishnoi, University of Calgary

Seafloor Stability

Dr. Sivakumar Subramanian, ChevronTexaco

Education

The Center has three key sustainability-related education initiatives:

- Support of interdisciplinary research related to sustainability.
- Development of course materials and approaches to education at the high school, university, graduate school and corporate education levels.
- Linkage of Rice students with opportunities both within and outside of Rice that enhance their knowledge of sustainability.

This report previously addressed the Center's support of interdisciplinary research. The Center seeks to introduce Rice students to the work of Houston-area businesses that are developing and applying sustainability-related practices. To illustrate, we feature the work of two Rice students at a Houston ship channel chemicals recycling facility, which is developing cutting-edge approaches to reducing emissions and improving energy efficiency. This section also addresses efforts of the Center to apply a new sustainability education module, known as "Chronos," — developed by Cambridge University and the World Business Council for Sustainable Development — to various levels of education. Featured is the work of the Center to help launch the module at Pinedale High School in Pinedale, Wyoming.

STUDENT HOUSTON SHIP CHANNEL CASE STUDY

Matt Hotze and Christine Robichaud, students in the Professional Science Master's Environmental Analysis and Decision Making program, embarked on a fall 2003 case study of the Houston-based Keeshan and Bost Chemical Company, owned and operated by Rice alumni Dr. Andrew Schwartz and his wife, Sue Schwartz. Since the late 1970s, this North Brazoria Co. area business has focused on buying co-product streams from other chemical processors and converting them into marketable materials. These streams would otherwise become wastes. The Schwartzes have granted a series of interviews and tours to allow the Rice students open access to information regarding their operations and business objectives, in this way offering insight into real-world applications of sustainable development innovations.

The case study currently underway will explore the history, philosophy and technologies behind this company's innovations in sustainability. Specifically, three innovations implemented at the Keeshan and Bost Chemical Company plant will be the focus of the study:

- Design and use of stationary elevated pipes attached to cooling towers in the manner of a ship's sail, for cooling product with natural Gulf Coast winds rather than water.
- Use of compressors and engines that capture byproduct off-gases, both minimizing waste gas release and generating electricity (30 percent of that used by the facility).
- Design and use of the first completely closed wastewater treatment tanks.

CHRONOS INITIATIVE

The World Business Council for Sustainable Development is a global organization that has approximately 175 member companies. WBCSD has teamed with Cambridge University to develop an e-based learning tool focused on teaching entry-level employees and middle managers approaches to sustainability, with a strong focus on stakeholder relationships.

The Shell Center has been working with WBCSD and Cambridge on using Chronos as a learning tool at the high school, university, graduate school and corporate education levels.

PINEDALE, WYOMING INITIATIVE

Pinedale, Wyoming, is located between the Wind River Mountain Range, Green River and the Pinedale Anticline, the site of a major natural gas production field. It also hosts the largest migration of large game in the lower 48 states, where some 30,000 pronghorn Elk and 43,000 mule deer migrate south from Yellowstone through this energy production area.

The Pinedale area presents numerous sustainability challenges with a full range of economic, social and financial considerations. The Shell Center now is working with Pinedale High School on the development of an education program focused on sustainability and stakeholder relationships.

2004 Highlights

The research activities approved in 2003 will begin in 2004. The Center anticipates conducting seminars related to this research. For example, Shell Center, in conjunction with Rice University's James A. Baker III Institute for Public Policy and Rice's Environmental and Energy Systems Institute, will host a **major international conference on gas hydrates**.

Other outreach activities will include a spring **seminar series on water**, focusing on water supply, potable water quality, coastal and surface water quality, flooding and watershed management.

Related to our ongoing air quality research and outreach efforts, we also will be conducting a conference in May on **"sustainable mobility,"** focusing on transportation challenges faced by cities in developing and developed countries. Also in midyear, the Center and the James A. Baker III institute for Public Policy plan to host the **Pew Center for Global Climate Change**, which will present findings of a major study on "U.S. Energy Scenarios for the 21st Century: Implications for Business."

In the fall of 2004, the Center plans to hold a conference on stakeholder relationships between NGOs and companies in the energy sector.

The Pinedale Wyoming initiative is expected to continue through 2004.

In the education area, the Center anticipates that it will work with a minimum of one high school in the creation of a sustainable development course focusing on stakeholders, as well as the inclusion of a sustainability course as a component of Rice University's Jones School of Management Corporate Education Certificate Management Course.

Other activities will focus on the business case for sustainable development, providing opportunities for faculty, staff and students to study how Houston-based businesses meet their commercial objectives and achieve positive environmental and social impact.

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