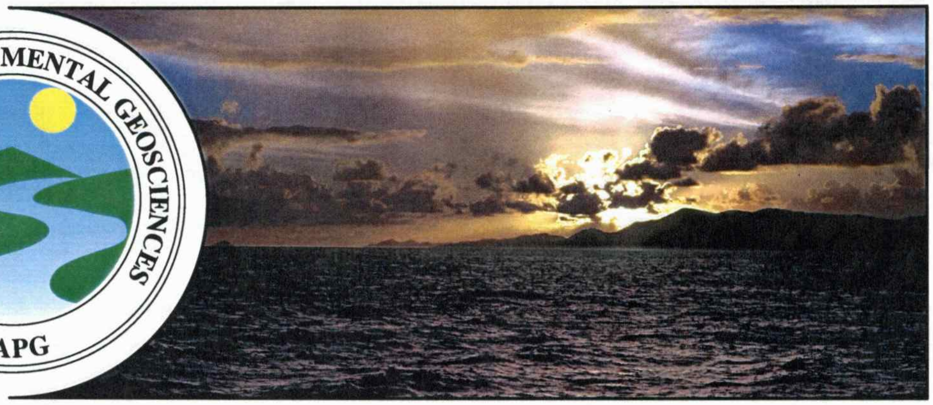

Water and Energy, the Basis of Human Society:
Are They Globally Sustainable Through the 21st Century?

October 8-11, 2000
Arbor Day Farm, Nebraska City, NE

Briefing to Kansas Senate Utilities Committee

January 25, 2001

CONFERENCE REPORTS

and

ADDITIONAL MATERIALS

Lee C. Gerhard
Kansas Geological Survey
And
University of Kansas Energy Research Center

Sponsored by the Division of Environmental Geosciences, American Association of Petroleum Geologists; Geological Society of America; American Geological Institute; the United States Geological Survey; the United States Department of Energy; and the University of Kansas Energy Research Center.

KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 2001-3

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Additional Materials

by

Lee G. Gerhard

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Kansas Geological Survey
1930 Constant Avenue
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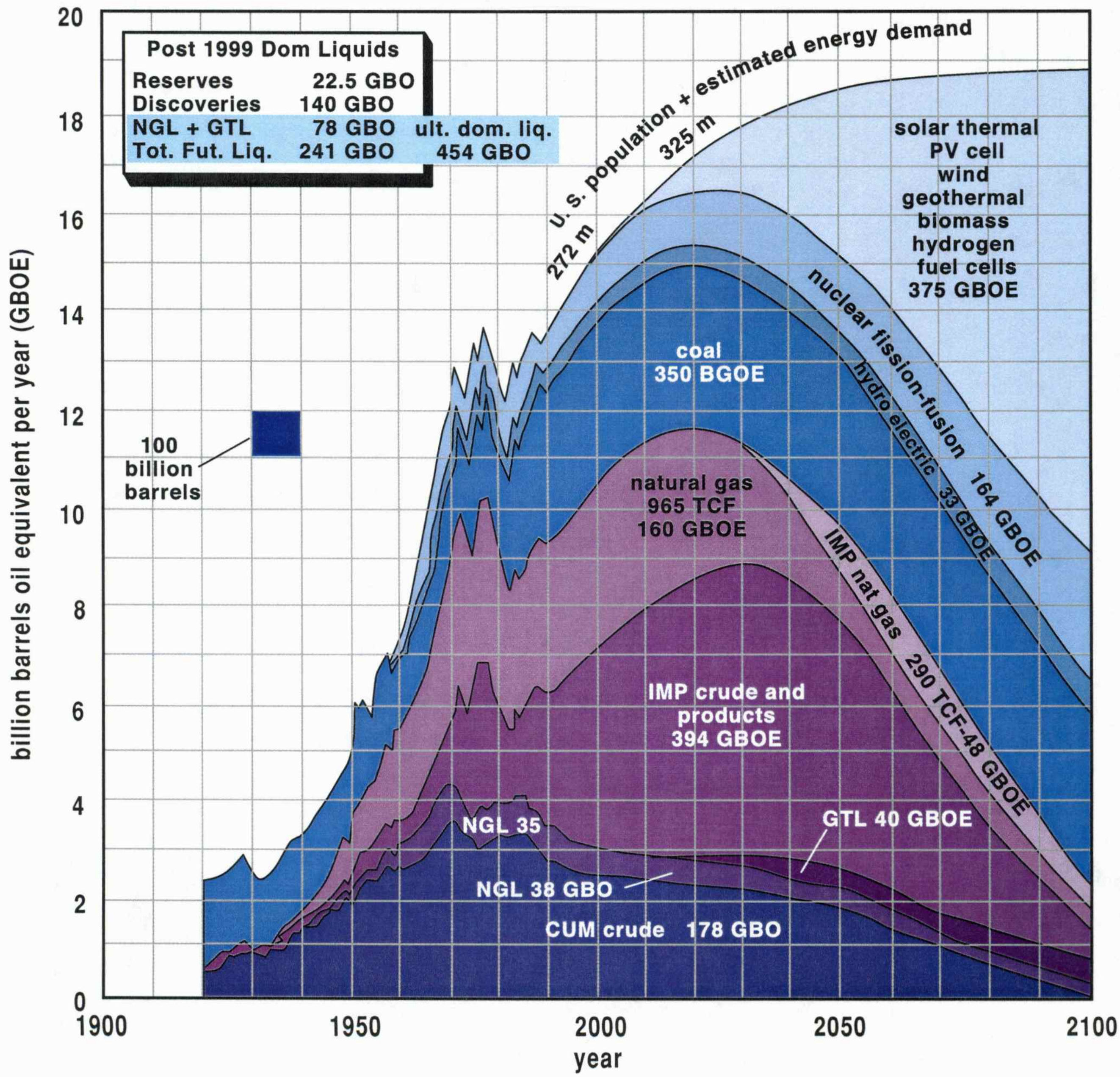
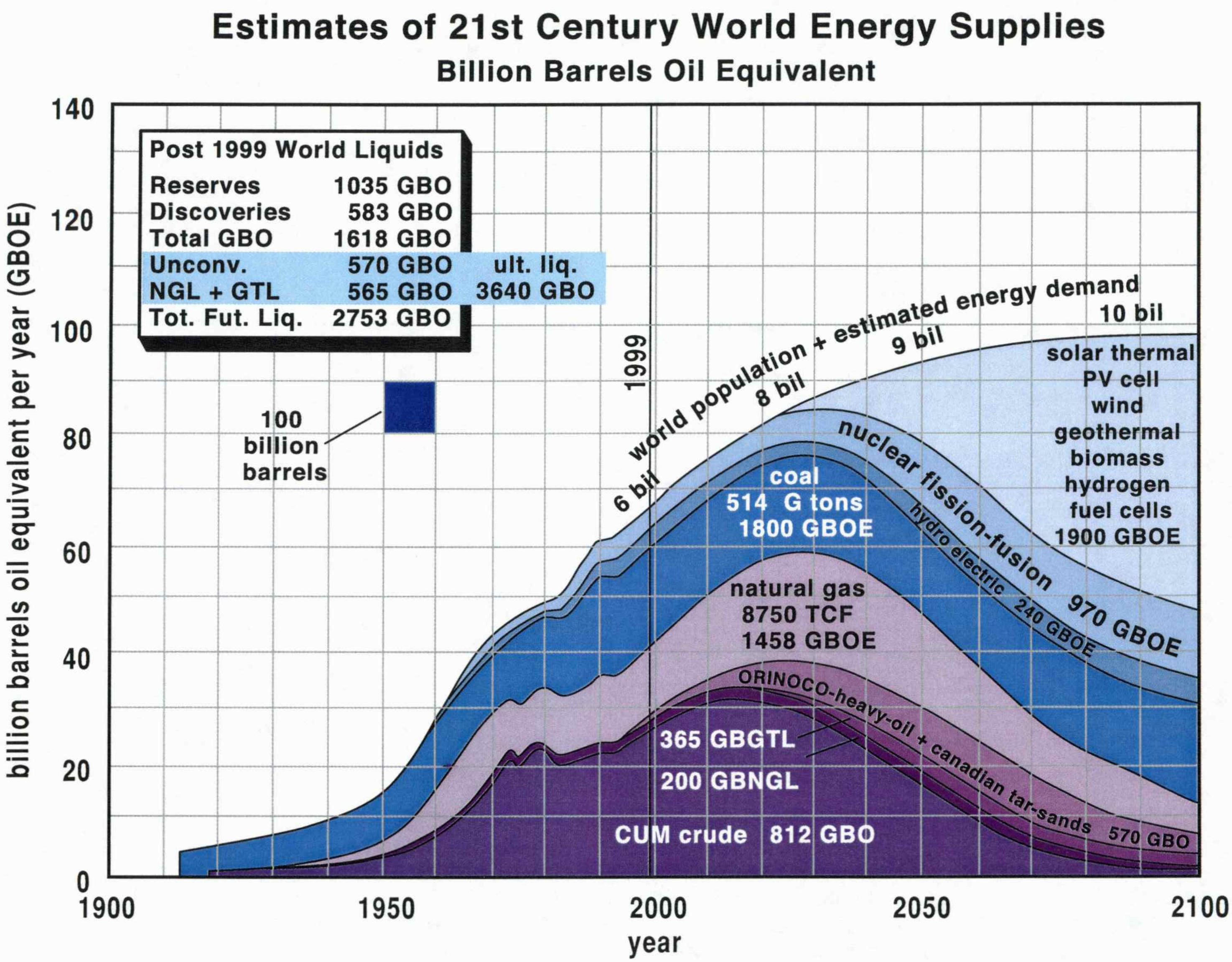
Lawrence, KS 66047-3726

Estimates of 21st Century United States Energy Supplies

Billion Barrels Oil Equivalent



SOURCE: John Edwards, University of Colorado



SOURCE: John Edwards, University of Colorado

Executive Summary: Energy

Lee C. Gerhard
University of Kansas Energy Research Center

* The world consumes around 27 billion barrels of oil per year. Reserve additions, including discoveries of new oil resources, are significantly less than that, about 10 billion barrels in 1998. There is a 17 billion barrel *petroleum deficit.* By 2050 supply will be less than demand, according to many knowledgeable scientists.

*These numbers are not a real indicator of the potential for future petroleum production throughout the world. There is more oil to be discovered in the world, and many regions have not been adequately explored by the drill.

*Petroleum supply is very price sensitive. If the price is allowed to reach demand-discouraging high levels, the supply of petroleum essentially becomes inexhaustible. When the price rises to $500 per barrel, it is doubtful that society will be driving many automobiles or disposing of plastic trash bags in the manner done today. There would still be a pharmaceutical industry, because the value of medicines is not very dependent on the value of the feedstock.

*Renewable energy is not likely to provide any significant portion of the nation's energy budget. Excepting hydroelectric facilities, traditional renewable energy sources are primarily useful for local and limited applications. Wind, solar, biomass, geothermal, and ocean tides seem to promise essentially limitless "free" energy, but barriers to their use are legion and none has yet been able to supply nationally significant amounts of useful energy. For example, replacing one 24 megawatt electric generating plant in Kansas would require constructing and operating 24,000 wind turbines, 24 hours a day, 365 days a year.

*Coal remains the fuel of choice for electrical generation in the near future.

*In the next twenty years it is anticipated that fuel cells, fueled by natural gas, may be the first replacement for petroleum products in transportation. Already used in space, fuel cells have potential to become the first practical alternative to petroleum transportation fuels, as part of the trend toward higher hydrogen content fuels.

*Natural gas is touted as an environmentally benign boiler fuel for making electricity, but the demand for natural gas is rising in many other sectors. The major constraint on natural gas supply and price is simply access to the national resource base.

*Unconventional fossil energy resources (such as tar sands, tight gas sands, and oil shales) may hold the key to supplying the world with energy over the next century or two. But the implied caveat for using unconventional fuels is development of cost-efficient and environmentally benign technology to extract, refine, and use those fuels. The tradeoff is disturbance of land, modification of the landscape, and the need to dispose of the waste products of production.

*The costs of the new technology required to use these fuels is such that they can become part of the fuel mix only after the price of conventional petroleum, coal, and natural gas become high enough to make investments in the unconventional fuels economically attractive. One price to be paid is the increasing input energy required to produce the present level of energy output.

*One potential bright spot is natural gas hydrates from the deep ocean and from Arctic permafrost zones. Estimates of potential recovery range from extremely large to small. Most estimates are quite large. The potential for a significant amount of energy from natural gas hydrates is high, but the time frame for development is likely to be decades. Natural gas hydrates will not be a low cost resource no matter how much becomes available because of the harsh and challenging environments in which they occur.

*Nuclear power must again become acceptable in the United States. Electric power generation from nuclear fuels is the single clear technologic and practical solution to significantly increasing the supply of electricity to the nation without using larger amounts of coal.

*The long term solution to creating a sustainable energy supply lies in new and unconventional thinking. Almost all the debate on energy sustainability involves using known fuels and energy resources. We need new ideas and new paradigms. Unconventional thinking is necessary to solve our conventional problems.

* No other single factor is as important in assessing energy sustainability than global population. Demand growth limits sustainability. Global population growth has been exponential, and does not yet show signs of abating. The supply of cheap petroleum to sustain present levels of consumption will not likely be sustainable through the end of the 21st century, unless global population is stabilized.

*If we were to bring the world standard of living up to United States levels, sustainability of current energy supplies is already suspect.

Personal Recommendations:

(1) Engage in efforts to develop a balanced energy supply policy. Support a national energy supply policy that includes access to domestic resources and research into unconventional, renewable, and theoretical energy supplies.

(2) Engage the people of Kansas in a continuous dialog about energy use, costs, and supplies. Let the people who use the energy, complain about the costs, and worry about supply, own the problems.

(3) Analyze and forecast Kansas' future energy supply, develop research–based conservation and energy efficiency programs, and formulate tax and regulatory policies that will enhance Kansas' future energy supply.

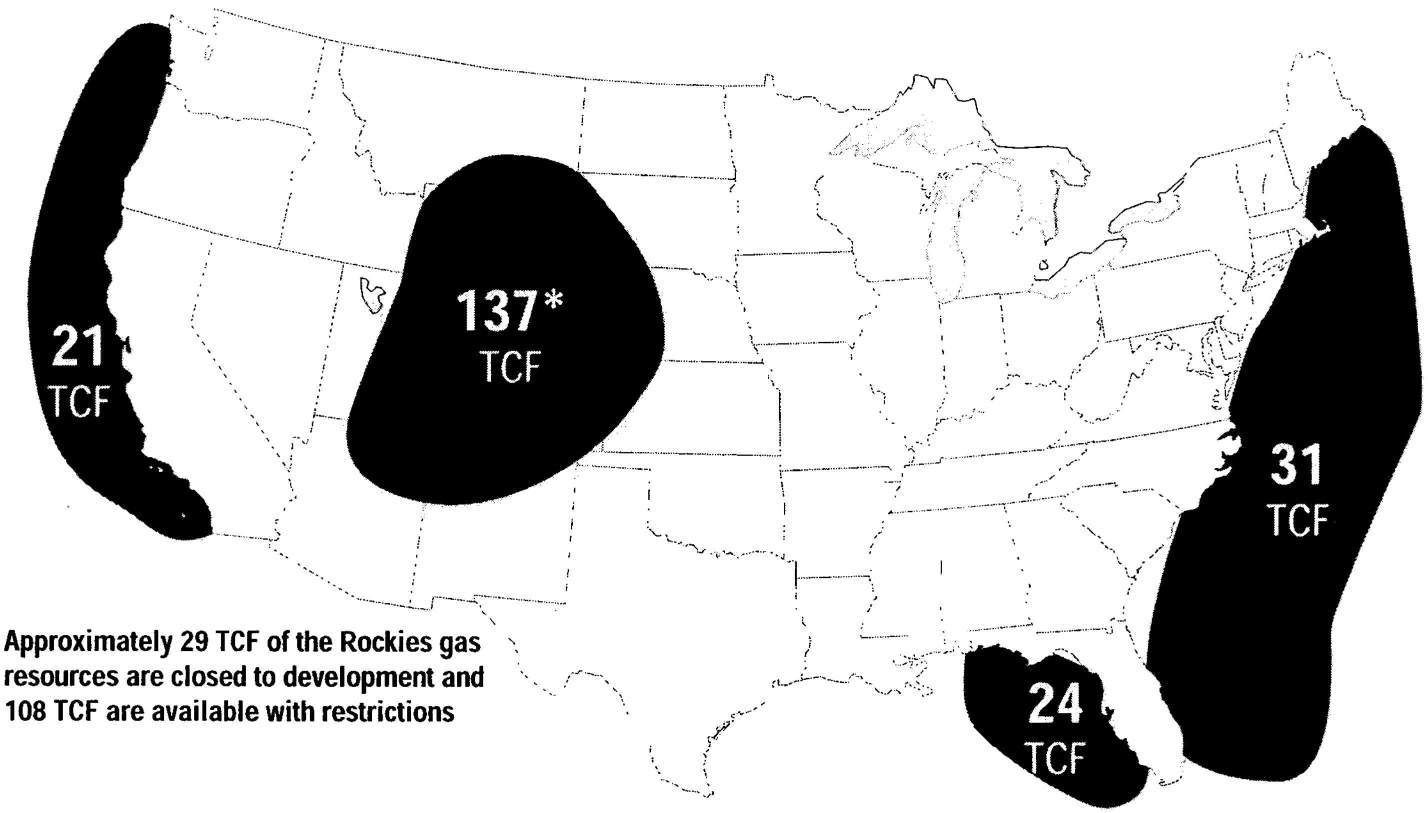
(4) People use and consume resources. We must recognize that population growth will continue to be a major factor in any resource supply policy.

(5) Enter, engage, and promote a debate over electric power from nuclear energy based on science rather than perception.

(6) A legislative resolution strongly encouraging development of a federal energy policy would be useful for the energy policy conference we are holding in Washington, D. C., on April 23.

(7) The Kansas Geological Survey has been trying to fund the Energy Research Center as a broad-based and Midwest-focused regional research center, using its authorization from Congress in 1992. We have not been successful. I personally recommend that this effort be reviewed as an integral part of a potential state energy policy.

Lower 48 - Natural Gas Resources Subject to Access Restrictions



* Approximately 29 TCF of the Rockies gas resources are closed to development and 108 TCF are available with restrictions

Significant amount of resource is subject to access restrictions

National Petroleum Council, December 1999

Report of Conference Activities

Water and Energy, the Basis of Human Society: Are They Globally Sustainable Through the 21st Century?

October 8-11, 2000

Arbor Day Farm, Nebraska City, NB

Sponsored by the Division of Environmental Geosciences, American Association of Petroleum Geologists; Geological Society of America; American Geological Institute; the United States Geological Survey; the United States Department of Energy; and the University of Kansas Energy Research Center.

Compiled by Lee C. Gerhard, Conference Chair
University of Kansas Energy Research Center
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Lawrence, KS 66047

The issues:

The Earth is a finite dynamic system, with practical limits on both the quality and quantity of its natural resources. Earth resources and biogeochemical processes are the ultimate arbitrators of the human condition.

Civilization has thrived because of easy access to natural resources from the Earth. Strangely, however, geology and the earth sciences have not played a significant role in public policy discussions about resource sustainability, with the result that misconceptions abound and misunderstandings characterize the discussions. The inextricable linkage of geologic (abiotic) resources with biologic (biotic) resources requires that earth scientists engage their colleagues in the life sciences as colleagues in discussions of "sustainability."

Earth resources, especially water and energy, are essential to preserving the fabric of society. Quality of human life and indeed, human life itself, depends on both. If human population continues to increase geometrically and the quantity of either potable water or economical energy is truly finite, improving the quality of life for most individuals and the global human condition generally is unlikely.

The Earth Science community is ethically required to provide policy leadership concerning earth resources (metals, industrial minerals, potable and process water, energy, and soils), geologic hazards (earthquakes, landslides, volcanic eruptions, floods, stream channel changes, shoreline erosion, and natural climate change), and to provide knowledge about the human context.

Serious questions have been raised by society about our ability to supply sufficient economical energy and water of appropriate quality to sustain the rapidly growing human population though the new century. Throughout the world, rising expectations of an improved material standard of living for all people exacerbates potential shortages of natural resources. Globalization of trade and economic development has brought globalization of expectations.

One scientific question is, "Are potable water and economical energy truly finite, or do the apparent limits on their quantity merely represent technological opportunities?" The answers to the concomitant social and political questions, "Are there truly ethical dilemmas as well as economic dilemmas to resource supply and consumption?" depend on the answers to the first scientific question.

Addressing the questions:

The conference addressed these questions in a series of formal papers, informal discussions, breakout groups, and assembly of policy recommendations. The participants (list appended) represented a very broad cross-section of technical and social backgrounds, ranging from the leadership of the American Association of Petroleum Geologists to the founders of the American environmental movement. Philosophers debated with water supply experts, and a legislator and a rancher brought reality to academic viewpoints. Life scientists brought biodiversity to debates on energy access. In all, an extremely diverse group of interested participants brought with them an equally diverse set of opinions and knowledge bases. The conference was enriched by the expertise of all. All benefited from the exchange of ideas and sharing of knowledge bases. Everyone came away with a broader appreciation of the complexity of the issues, and some consensus was reached on the policy required to address these critical problems.

A book of pre-conference papers was provided to the participants, containing the essence of all the technical presentations. The results of the conference will be compiled and published, including final papers by the presenters and a summary of the conference discussions and conclusions. The conference was video-taped, providing a final arbitrator of conference work. There are no plans to compile a video presentation of the conference, but that remains a possibility if the participants desire it and sufficient funding is available to do the editing.

The program:

Victor Yannacone, environmental attorney, who filed the first successful legal challenge to the use of DDT and together with his wife Carol, also a participant, established the environmental movement in 1966 opened the conference with a Sunday night keynote on the ethics of sustainability. He spoke about the need to identify the resource base, to consider carefully the effects of our burgeoning global population, and what are the effects of constraining consumption. Drawing upon more than 30 years of extensive public interest litigation including *Agent Orange* and saving public lands, Yannacone considered the equitable distribution of natural resources in the context of the Law of Equity which is the means by which the ancient concepts of the "natural law" have entered Anglo-American jurisprudence. Equitable distribution of water and energy to all the peoples of the world is another issue that must be addressed, unless we find a way to produce surplus water and energy. Agriculture is the link between energy and water. Human life cannot survive without water, and human society cannot survive without energy. "Sustainable" and "sustainability" need to be defined in terms of sustaining what? for whom? at what level of consumption? and, for how long?

Energy

Marlan Downey, President of the American Association of Petroleum Geologists, led off the discussion of energy sustainability. His presentation recorded the progress of technology in solving the energy and resource problems of mankind. As he pointed out, "We didn't leave the Stone Age because we ran out of stone!"

Rather, we have used better technology to increase the supply of resources, and to increase the efficiency of their use.

Dr. John "Jack" Edwards, University of Colorado presented the alternate view of energy supply, showing by his calculations that we will have a national and global under-supply of fossil and alternative energy by 2020. His arguments underscore the need for research and development of additional new and efficient energy supplies, including nuclear, if we are to forestall major global economic collapse when the supply of fossil energy peaks and countries face increasing prices for fewer energy supplies.

Dr. Everett Sondreal, University of North Dakota Energy and Environmental Research Center, spoke to the issues of using coal as an energy source and the electrical generation industry in general. He argued that coal will retain its dominance in the electric power industry through 2020, but that new plants will be much more likely to be fired with natural gas. Coal plant emissions are the major issue for continuing coal use. If the supply of natural gas and oil declines enough to raise prices, the world will have greater dependency on its coal resources. Access to the natural gas resource base, keeping costs high, in the United States is one of the major obstacles to natural gas replacing coal as a boiler fuel.

Dr. Walter Youngquist, Consulting Geologist, retired professor, and author of the book *Geodestinies* spoke about alternate energy availability and development. He pointed out that alternative and renewable energy sources, including hydroelectric power, provide American society with less than 10% of its energy needs. As society moves into the post-petroleum age, where will our energy come from? Perhaps the earth can support at the most, two billion people in reasonable affluence on natural products. We had best get on with the task of planning for and developing replacements for oil, because now there are no acceptable nor technologically possible substitutes for oil.

Dr. Harrison "Jack" Schmitt, Apollo 17 astronaut and former U. S. Senator from New Mexico, spoke to solving energy supply problems with "out of the box" solutions. Almost all discussions about technology are about creating ways to continue to use the same fuel mix already in place. Jack briefed the participants about the progress of the plan to mine Helium 3 on the moon and provide Earth with a very long-term energy supply. While the concept is exciting in its own right, this demonstration that geologists don't have to be bound by current paradigms of energy supply initiated debate about other non-conventional energy resources.

The most important role of technology may be to replace current energy paradigms rather than extend their life. For instance, gas hydrates may have long term potential as an energy supply, but relatively few new technologies are needed to access it. There is no question among the participants that current views of renewable energy resources are not the solution to the problem. The massive amounts of energy needed to meet global aspirations for energy access and then to meet population growth demands are so immense that windmills, biomass, and other renewables have limited, if any, chance of making more than local impact.

Concluding the session on sustainability of energy, breakout groups answered the following questions:

(1) How can we define "sustainable energy supply?"
(2) How can we clarify and improve the public understanding of energy issues?
(3) What earth science components should there be in national energy policy?

Water

Dr. William Alley, United States Geological Survey, keynoted the session on sustainable water and pointed out some constraints on water sustainability,
(1) Water resources cannot be developed without environmental impact,
(2) Water sustainability must be defined in the context of the entire hydrologic cycle,
(3) Consideration of the topic requires long-term water management policy,
(4) Water sustainability is a perspective of the geographic scale examined, and
(5) Meeting the challenges of making water sustainable requires innovative approaches to all uses and supplies.

Dr. Charles Kreitler, consulting hydrologist, LBG/Guyton Associates, took a pragmatic view of the water issue. He spoke to the need to consider sustainability on the local level. Water issues are not global, they are local. Should we look for a global solution to a local problem, or try to solve the local problem locally? What role should environmental need for sustainability play versus human need? Addressing societal needs for consumptive use of water will eventually deprive ecosystems of water. Should water be treated simply as a commodity, or an entitlement? By treating water as a commodity, its price may rise depending on demand, and therefore we will be apt to conserve water. By treating water as an entitlement, the price will be kept low, and water may consequently be wasted. These and other questions generated strong debate.

Dr. James Triplett, Professor of Biology at Pittsburg State University, best summarized the issues by making the observation that there is enough fresh water on Earth to provide every human with about 400,000 gallons per year. Supply is not the problem. The location and distribution of the supply are problems. The dominance of humans in the ecosystem has made other organisms suffer deprivation of water, but humans need the other organisms to survive as well. There is a conflict of interest that is not easily resolved. Virtually all systems are impacted by human activities, there is really no "pristine" system left. So we are really left with making informed decisions about allocation.

Dr. Thomas Scott, Florida Geological Survey, outlined the history and geological issues surrounding the Everglades water supply and the huge federal program to restore the Everglades. Tom illustrated the geologic setting and the development history of the water resources of the Everglades region. Changes in federal policy towards water use are the driver behind both the loss of water to the system and the new program to restore the ecology of the Everglades through better use of water. Geological constraints control how the restoration takes place. It is not yet clear that the program will be successful, as natural changes take place at the same time as artificial changes. Restoration ecology may never restore the system to an original state, which has naturally changed through time.

Conference Chair Lee Gerhard articulated the Kansas state water management system as an example of governmental foresight. The plan is citizen-based, scientifically valid, and provides for no one person to drive the management system. Rather, a collegial system of checks and balances operate to manage water in an irrigated agricultural state where rainfall ranges from less than 20 inches per year in the west to over 40 inches per year in the east. He described the geometry of the system and how it worked to the benefit of all.

Concluding the session on sustainability of water, breakout groups considered the following questions:

1. How can we define “sustainable water supply?”
2. How can we clarify and improve the public understanding of water issues?
3. What earth science components should there be in national water policy?

Concluding activities

The concluding presentation of the conference was an ethical and anthropologic summary of the issues by Dr. Timothy Weiskel, formerly of the Harvard Divinity School, where he lectured on environmental and resource ethics, now a lecturer at Tufts University. Dr. Weiskel presented a view of anthropologic history that has led to the present state, from hunter-gatherers without competition and structure to sessile agricultural economies that developed possessiveness and defensiveness of their resources and for whom population growth became a power base. This is related to the issues of sustainability and equity in resource access as a cultural constraint on our ability to adjudicate these issues. Technology may solve the supply issues, but never the equity issues.

The conference concluded with a plenary session devoted to identifying and prioritizing policy recommendations to address the two issues of sustainability, sustainable energy and sustainable water. The results of this effort are being tabulated and will be part of a final published report of the conference, to be published in a professional journal. Conferees will have opportunity to participate in the review of the to-be-published report. The report publication will include final papers from the speakers.

Results of the breakout sessions were:

Energy

1. How can we define "sustainable energy supply?"

Meeting societal demand in perpetuity is an ultimate answer for the question, but there are so many variables that it may not be useful to view energy sustainability in that manner. Energy sustainability can be viewed as a series of time and technology episodes. Rising global population, social expectations, and technology advances constrain the definition of sustainability as much as any finite volume of energy resources. While there is sufficient energy resource, including coal, nuclear, and hydroelectric to sustain society today, already the costs of the more desirable petroleum and natural gas resources preclude them being sustainable for less affluent societies and most developing nations. Technology advances can make some energy resources less expensive, but growing demand and growing population may override the technology advances. Call to mind how the United States legislated better fuel economy so that it imported less oil in the 1970's. The average mileage did go up, but so many new cars were added, along with moderate population increase, that we consume 25% more petroleum today than we did at that time.

Although the group considered global equity issues, renewables, and growth, these issues illustrate the problem, but do not contribute to the solution. European and North American social values may not be attainable or even desirable for other societies, although they may well aspire to the same comfortable material standard of living. Society will have sustainable energy supplies, simply because society is absolutely dependent upon energy. However, at what cost to life style and quality of life goals? No energy, no society. Providing energy supply sustainability in the long term will require unorthodox thinking, and population stability.

2. How can we clarify and improve the public understanding of energy issues?

To begin to address the larger issues of sustainability we must engage the public and give them ownership of the issues. Public education through established systems has not worked, in part because the teacher training system lacks the information to address complex energy issues. Various earth science societies have attempted public information programs, but they have been fragmented, incomplete, and generally lack staying power. Providing a balanced perspective of energy issues will require using the popular media and providing answers as well as issues. There needs to be a program that identifies the problems, gives a blueprint for the answers, builds consensus, and maintains its focus over a very long period of time.

Current high petroleum and electricity prices have created an opportunity to mobilize the public, if we had a program to market, governmental support, and could demonstrate progress. One highly charged issue that can be easily addressed today is that we have a policy to use natural gas, but no policy to access the resource base. Leadership by the earth science professions would be a place to start. Part of the problem could be that people are not connected as well today as they had been, owing to isolation caused by electronic media and communication and other workplace sociological phenomena.

3. What earth science components should there be in national energy policy?

Participants ranked their top ten potential energy policy recommendations:

(1) Develop a grass roots educational effort towards public understanding that our energy future requires us to lose our addiction to fossil fuels and to develop awareness that unconventional energy sources are the future.

2) Using a peer review process, establish communication on local, state, and federal level in the United States, on broad scientific concepts necessary to deal with Energy and Water needs over the 21st Century. A concerted effort is needed, and should be led by scientific organizations such as the AAPG.

(3) Engage the people of the United States in a continuous dialog about energy use, costs, and supplies. Make the people who use the energy, complain about the costs, and worry about supply, own the problems.

(4) Engage in interdisciplinary efforts. Take the time and trouble to communicate with ecologists to ensure that each equally addresses the other's concerns. Work with people who know how to communicate. If the earth sciences and life sciences can't work together, there will be no progress toward a balanced energy supply policy with access to domestic resources.

(5, 6) (Tie vote with next item) Fund research to meet the goal that 40% of energy use shall come from unconventional or renewable sources in 15 years.

(5, 6) (Tie with vote preceding item) Educate policy makers about energy supply issues. Create venues that address specific policy issues from a scientific perspective, but with broad public appeal, such as a conference on the need for a national energy supply policy.

(7) Convince people in the United States that continuous unlimited growth cannot be sustained without a significant decline in lifestyle.

(8) Develop research–based conservation and energy efficiency programs.

(9) People use and consume resources. Public policy must recognize that population growth will continue to be a major factor in any resource supply policy.

(10) Earth scientists must enter, engage, and promote a national debate over electric power from nuclear energy based on science rather than perception.

Water

1. How can we define "sustainable water supply?"

A sustainable water supply is a potable water supply that meets all the needs of humanity in perpetuity. Although society is dependent upon energy, life itself is dependent on water. Sustainability of water has a strong local context, since water has a high "place value" as compared to petroleum for energy, issues of contamination and overuse are local, and climate impacts on the hydrologic cycle are local or regional. However, these local issues when taken in toto may become more global, especially as population increases.

Such a definition does not adequately address ecosystem water requirements specifically, but indirectly the need for ecosystem services by humans imparts a priority to ecosystems for water access.

Creating a sustainable water supply in some geographic areas will require significant investment, which the local area may not be able to afford. So providing a perpetual water supply for some parts of society may require charitable investment or the translocation of communities.

Approaches to assure a perpetual supply of potable water include minimizing contamination, efficiency of use, restricting growth to water resource capacity, and technological breakthroughs. The same overriding issue as energy is the exponential growth of global population and consequent future expected societal demands. Water must be fully valued if it is to be conserved.

2. How can we clarify and improve the public understanding of water issues?

The public generally does not understand the true cost of water, the hydrologic cycle, the intersection of surface, groundwater, and marine waters, and natural water qualities. However, in those settings where the public has had opportunity to examine the issues and have a voice in solutions, public input often surprises experts with its sophistication. In this context, water issues are local enough that giving people ownership of their problems will likely mean that they will take action.

Providing the public with information about full water costs, and the overarching mandate that any water development has impacts and thus tradeoffs, then the answers are likely to be practical. The earth science professions are good candidates for providing information, but only if the information is given in terms the public can understand and with which they can work.

3. What earth science components should there be in national water policy?

Participants ranked their top ten potential water policy recommendations:

(1) National and regional policy should recognize the full cost of water resource access, including the depletion of fossil waters and disposal of wastewater. In general, water is valued too cheaply for effective management.

(2) A water resources website should be constructed that provides water resources information to the public and also links to other web resources. The site should be designed for the general public but the content should be peer-reviewed. The United States Geological Survey should host the website, with a committee of external reviewers to provide oversight. The website should clearly demonstrate the relations between water & energy.

(3) Concerted effort on education on water supply issues– all forms, all levels.

(4) Policy should address impact of water supply on ecosystems, especially aquatic ecosystems.

(5) Synthesize the global water supply and demand by regions to define problems. A GIS approach would be useful.

(6) Policy should regard water supply as a single system based on watershed management, so that full integration of data occurs.

(7) Establish energy levels necessary (BTU's) to provide any given amount of water – and what quality of water.

(8) Support further research in dry land agricultural practices, to understand how to convert irrigated agriculture to dry land when irrigation water becomes either unavailable or too expensive to use.

(9) Water use trend is toward water going to non-agricultural uses. Urban/Industrial demand takes precedence over agriculture now, and will

continue to do so in the future. Urban/industrial can pay more, so how will agriculture persist?

(10)Support an increase in federal funding for research on cost-effective desalination.

Appendix A. Conference participants

Samuel Adams
Consulting Geologist

William Alley
USGS

Gerry Calhoun
New Paradigm Explor. Inc.

Marlan Downey
AAPG

Jack Edwards
University of Colorado

Priscilla Grew
Univ. of Nebraska-Lincoln

Lee C. Gerhard
KGS

Rep. Carl Dean Holmes
KS House of Representatives

Charles Kreitler
LBG-Guyton Associates

Jane C.S. Long
Univ. of Nevada-Reno

Pat Leahy
USGS

Monte Naylor
Diversified Operation Corp.

Ronald A. Nelson
BP Amoco

A.R. Palmer
Inst. Of Cambrian Studies

Harrison Schmitt
University of Wisconsin

Thomas M. Scott
Florida Geological Survey

Everett Sondreal
University of North Dakota

Marios Sophocleous
Kansas Geological Survey

Stephen Testa
Testa Environmental Corp.

James Triplett
Pittsburg State University

Sidney Warner
Warner Ranches, L.P.

Tim Weiskel
Harvard Divinity School

Carol Yannacone
Yannacone & Yannacone, P.C.

Victor J. Yannacone, Jr.
Yannacone & Yannacone, P.C.

Walter Youngquist
Consulting Geologist

Organizing Committee Perspectives on Energy and Water Sustainability through the 21st Century

Lee C. Gerhard
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Water sustains all life on earth; energy sustains human society.

Introduction

Sustainability of energy and water through the 21st Century was the daunting topic for an invited group of 25 experts gathered at the Arbor Day Farm, Nebraska City, Nebraska, October 8–11, 2000. Sustainability of what? for whom? at what rate of consumption? of what quality? and for how long? were questions raised in every discussion. Eventually, the participants selected ten policy recommendations by a cumulative voting process from more than 30 suggested for each resource. However, the selected policy recommendations do not reflect the full spectrum of the discussions.

Therefore the conclusions of the Conference are synthesized and supplement the policy recommendations with information presented by keynoters and developed during the discussions and consensus-building exercises. The reader is referred to reports of two conferences on resources, environment, and society that preceded this meeting (Gerhard et al, 1996; Gerhard, 1999) for additional background.

Energy sustainability

The world is consuming around 27 billion barrels of oil per year. Reserve additions, including discoveries of new oil resources, are significantly less than that, about 10 billion barrels in 1998 (Energy Information Adminstration, 2000). The disparity between additions and consumption is the *petroleum deficit.*

Recognizing that exploration and development of petroleum has been hampered in recent years by low prices, these numbers are not a real indicator of the potential for future petroleum production throughout the world. Nonetheless, these numbers do suggest that there is a long-term shortfall between production and discoveries, one that will likely increase with time.

As Downey (this volume) points out, "We didn't leave the Stone Age because we ran out of stones." There is more oil to be discovered in the world, and many regions have not been adequately explored by the drill. There are many very large known petroleum resources that we have not yet exploited because of price and technology. This argues that there is a lot of oil yet to be discovered and produced in the world.

Edwards (this volume) suggests that by 2050 supply will be less than demand, and that other energy resources will be required. Edwards argues that petroleum is a finite resource, soon to be scarce. These two papers illustrate the disparate views in the current debate on future petroleum energy supply and demand.

Petroleum is very price sensitive. Increasing global demand with a constrained supply simply increases price, whether the constraints are natural or artificial. If this is correct, when demand finally exceeds supply, the price will rise until demand is suppressed. The period of time during which petroleum can be used for low cost personal transportation and inexpensive disposable plastic products may come to an end sooner than many of us might wish. Under one extreme scenario, if oil becomes scarce enough for the price to rise to $500 per barrel, there would still be a pharmaceutical industry, because the value of medicines from petrochemicals is not very dependent on the value of the feedstock. However, at that price it is doubtful that society will be driving many automobiles or disposing of plastic trash bags in the manner done today.

The amount of residual oil in abandoned shallow oilfields and in tar sands is sufficient to meet any expected need for pharmaceuticals. If the price is allowed to reach demand-discouraging high levels, the supply of petroleum essentially becomes inexhaustible.

Alternative and renewable energy sources continue to receive much attention from the mass media. Unfortunately, media coverage provides limited information and demonstrates little knowledge of total global energy use and production. Wind, solar, biomass, geothermal, and ocean tides seem to promise essentially limitless "free" energy, but barriers to their use are legion. Despite billions of dollars invested over decades, none of these sources has yet been able to supply significant amounts of useful energy. Some, such as grain alcohol currently require more energy to produce than they can deliver as fuel. (Younquist, 1999, this volume).

For example, replacing one 24 megawatt electric generating plant in Kansas would require constructing and operating 24,000 wind turbines, 24 hours a day, 365 days a year, unlikely even in western Kansas. Evenly distributed, each of the 105 Kansas counties would have about 229 turbines, but since not all counties have good wind sources, there would be uneven distribution of the towers.

In order to gain the efficiency of the single fossil-fueled plant, there would have to be about 4 times the number of turbines (more than 800 per county), because the wind does not blow constantly enough throughout the State. In addition, the wind turbine fields would require batteries that could store the power, and so on. Coal remains the fuel of choice for electrical generation in the near future (Sondral, this volume).

Excepting hydroelectric facilities, traditional renewable energy sources are primarily useful for local and limited applications. Solar power has supplanted wind power on many ranches for pumping remote water supplies. While these remote and local applications of alternative non-traditional energy sources are useful, efficient and deserve further development, they will not power large cities. There is potential for wider application of solar energy conversion if efficiencies can be improved.

Unconventional fossil energy resources may hold the key to supplying the world with energy over the next century or two (see Downey, this volume). But the implied caveat for using unconventional fuels is development of cost-efficient and environmentally benign technology to extract, refine, and use those fuels.

Tar sands, oil shale, and tight gas sands all contain huge amounts of petroleum. The tradeoff for access is disturbance of the land, modification of the landscape, and the need to dispose of the waste products of production.

The costs of the new technology required to use these fuels is such that they can become part of the fuel mix only after the price of conventional petroleum, coal, and natural gas become high enough to make investments in the unconventional fuels economically attractive. Use of these unconventional fuels can extend the energy supply at current levels of consumption for additional decades. The price to be paid is the increasing input energy required to produce the present level of energy output.

One potential bright spot in the energy supply picture is the possibility of accessing natural gas hydrates from the deep ocean and from Arctic permafrost zones. Estimates of potential recovery of methane (natural gas) range from extremely large to small (Kvenvolden et al, 1993; Harrison, W., pers. comm.). Most estimates are quite large.

One of the unique characteristics of natural gas hydrates is that they are an apparently renewable resource, even on human time scales. Exploitation problems involve actually locating mineable deposits, and developing the technology to safely extract and expand them from their "natural" crystalline state to a useable fuel gas. Under surface pressure and temperature conditions, they expand explosively.

The potential for a significant amount of energy from natural gas hydrates is high, but the time frame for development is likely to be decades. Natural gas hydrates will not be a low cost resource no matter how much becomes available because of the harsh and challenging environments in which it occurs and from which it must be extracted.

In the next twenty years it is anticipated that fuel cells, fueled by natural gas, may be the first replacement for petroleum products in transportation. Already in use in space, fuel cells have potential to become the first practical alternative to petroleum transportation fuels, as part of the trend toward higher hydrogen content fuels (Fisher, 1999).

Fisher (his figure 3) demonstrates that the hydrogen content of fuels has increased over time in a natural progression. Wood (H/C=0.1) was the energy base until major utilization of coal (H/C=1), then oil (H/C=2). Now, and in and immediate future, natural gas (fossil methane, H/C=4) will be the fuel of choice. The midpoint and turning point for decreased carbon and increased hydrogen content is about 1935, when the petroleum economy was established. Fisher projects that there will be a non-fossil hydrogen economy starting in about 2025, established by 2050, and by 2150, a full hydrogen economy. The USDOE is sponsoring a demonstration fuel cell electrical generating station for the USEPA Environmental Science Laboratory at Ft. Meade, Maryland (U. S. Dept. Energy, 2000).

Natural gas is touted as an environmentally benign boiler fuel for making electricity, but the demand for natural gas is rising in many other sectors. The major constraint on natural gas is simply access to the resource base (National Petroleum Council, 1999). Aesthetic and scenic vista restrictions on access to the near offshore coastal waters and the Rocky Mountains have greatly curtailed the potential for natural gas production in the United States, even as the federal government encourages a switch from coal and petroleum to natural gas. As this is written, the nation reached its historic high natural gas price.

Nuclear power may again become acceptable in the United States when the cost of petroleum becomes high enough to seriously affect the average citizen and when the federal government can credibly assure the public that high-level long-lived radioactive waste can be safely disposed of and contained. Electric power generation from nuclear fuels is the single clear technologic and practical solution to significantly increasing the supply of electricity to the nation without using larger amounts of coal.

The long term solution to creating a sustainable energy supply lies in new and unconventional thinking. Almost all the debate on energy sustainability involves using known fuels and energy resources.

Schmitt (this volume) proposes a radically different alternative—mining Helium 3 (He^3) from the moon, transporting it back to Earth, and using its fusion energy to generate electric power. While the business plan for that proposal requires access to some advanced technology and may take many years to mature, it demonstrates the thinking that is necessary to solve many human problems throughout the world.

We need new ideas and new paradigms. Unconventional thinking is necessary to solve our conventional problems.

Other factors beyond supply affect sustainability. Global population growth has been exponential, and does not yet show signs of abating (Fig. 2). With present technology and at present use levels, the supply of cheap petroleum to sustain present levels of consumption will not likely be sustainable through the end of the 21st century, no matter how much more is discovered, unless global population is stabilized.

No other single factor is as important in assessing energy sustainability than global population. This question has not been addressed in the United Nations and appears to be beyond direct political action by any individual country. Education appears to be a key element to resolving this problem. Religious beliefs that favor unrestricted reproduction and national economic policies that favor large families over small are significant factors in the seemingly inexorable increase of global population. Sustainable energy for a 6 billion person world is a significantly more tractable problem than assuring sustainable energy for a 10 billion person world in 2050.

A very different issue but no less important in consideration of a globally sustainable energy supply is the equitable distribution of energy to all the people of the world. Much of the world's population has limited access to the energy needed for development of their society and maintenance of their culture.

If we are to bring the world standard of living up to United States levels, sustainability of current energy supplies is suspect in this century. There is little likelihood that North America and Europe will voluntarily decrease their standard of living.

Water Sustainability

The issues surrounding sustainable water are very different from those surrounding sustainable energy. There is sufficient water on and in the Earth to sustain global population for centuries to come, regardless of forecast global population increases. However, 97% of the Earth's water is not potable. Human beings and most other animals cannot drink it.

Oceans are saline, and most of the underground water contained in continental rocks is saline, often more salty than the oceans. Therefore, we must evaluate the availability of fresh waters developed during the hydrologic cycle (Figure 3), some of which is now (presently) fossil water, that is, water that was emplaced during the last glacial stage.

Fresh waters from the Hydrologic Cycle occur as streams, lakes, and groundwater. They are subject to the variations of the hydrologic cycle and changes in climate. They can be made useless by contamination or depleted by excessive use; or, they can be protected, managed, and sustain the human species as well as the diverse populations of plants and animals upon which human civilization depends (Kreitler, this volume; Alley, this volume).

Three major factors determine water sustainability.

- Freshwater does not occur evenly over the planet. The unequal distribution of fresh water means that some societies have an abundance of high quality fresh water, while others suffer greatly from having a small amount of not very good water.
- Freshwater is subject to an infinite variety of contamination. It dissolves many compounds and transports others easily. Maintaining water quality consistent with human consumption is not easy even in natural settings. Large concentrations of human beings inevitably exacerbate the problem.

- Water is required to maintain many natural ecosystems (Triplett, this volume). Overuse of the water resource harms such ecosystems, but we have not yet been able to quantify those effects on the human standard of living.

Water, unlike oil, has a high "place" value and a low "unit" value. That is, one doesn't normally pay a lot for water, but it has to be found near where it is used, as it costs a lot to move it from one place to another, like sand and gravel. Oil has a high unit value, and a corresponding low place value. Oil is sufficiently valuable and energy dense to make it profitable to move it from where it is found to where it is used, like most metals. <u>It is that difference that makes sustainable water a local issue rather than a global issue. The global nature of the hydrologic cycle, however, adds a global dimension even to the most local consideration of fresh water as a sustainable resource.</u>

For instance, in eastern Kansas, municipal water is taken from both surface reservoirs and rivers, and from groundwater wells. There is abundant water, rainfall approaches more than 40 inches per year, and there is no water supply problem. In western Kansas, there is no surface water available to municipalities. They are completely dependent on ground water.

In western Kansas, the City of Hays has inadequate well supply from its major stream aquifer, and has been supplementing its supply with brackish water from the Dakota Formation. Some of the ground water that is available has been inadvertently polluted in former years, and remediation is underway, but the pollution restricts the water supply even further. The city has purchased water rights from a ranch in another drainage. The costs to move the water, even if approval for an interbasin transfer is gained, will be in the tens of millions of dollars.

Hays has less than 25,000 residents, but has been on water rationing for more than ten years. They do not have a sustainable water supply, unlike much of the more populous eastern portion of the state. Appropriate management of water resources can mitigate many problems, but there are trade-offs that must be made (Gerhard, this volume).

Some of the western Kansas water supply problem is the result of depletion of the High Plains aquifer, so that surface springs that once fed the rivers no longer provide water. In addition, modern agricultural practices attempt to keep all precipitation on the land on which it falls, permitting as little run off as possible. Both of these practices have decreased the surface flow of streams, reduced the quantity of water available to the associated stream aquifers, and negatively impacted stream ecology.

Internationally, the problems are more severe. Much of central Africa, Australia, and the Middle-East are desert. Nationalistic fervor, cultural differences, geographically small nations, the need for agriculture, and limited surface waters have made this issue a military one in some cases. The potential for additional military action over water supply is high. Today, irrigated agriculture is a mainstay of the global food supply. There is not a sustainable water resource in much of the global desert. Population growth tends to be very high in those regions, creating further problems.

Along some of the world's largest rivers, where water is plentiful, contamination from human activity has extensively degraded water quality. Long term human settlement in the major river valleys has made the water difficult and expensive to treat. Among those rivers are the Mississippi, the Ganges, the lower Nile, the Mekong, and the Rhine.

There is a false perception that only third world nations have mistreated their water supplies. In America, thirty years ago water could be directly imbibed from glacial lakes and high country streams, but no longer. In the last few decades a micro-organism, *Giardia lambia,* apparently carried by recreational hikers, has contaminated these waters and made them undrinkable without filtering.

In major U.S. urban corridors, massive population growth has overtaxed water resources, so that increased population or significant drought causes water shortages. On Long Island, New York, overbuilding on groundwater recharge areas along with concurrent rapid population growth is overtaxing the sole source aquifer which holds the groundwater on which the people of the island subsist. There is no alternate potable water resource, but no regional water management system is yet in place. (Yannacone, pers.com., 2000). Artificial recharge and conjunctive use strategies will become more important issues in the future.

Desalinization through artificial evaporation is a standard potable water recovery process along desert coastlines, but it is very expensive and energy intensive. In addition, the distilled water requires mineral supplements before it can be used as drinking water. In U. S. funds, such desalinized water costs cents per gallon, as compared to gallons per cent for normal treated municipal water in the freshwater-rich areas of the world.

Where water is brackish, reverse osmosis can be used, but that process also is expensive, and the systems take much maintenance.

The most important municipal and irrigation water supply additions today are made by diversions of water. Unintended consequences of water diversions, including those of "safe yield" (Sophocleous, 2000) can have major environmental and supply impacts, such as has happened in the Aral Sea, where diversion for agriculture dried up an important fishing industry and polluted the remaining water, and created health problems.

Denver, Colorado, receives a significant part of its water supply from a western slope Rocky Mountain interbasin transfer, and one result is Mexico getting less than its adjudicated water supply from the Colorado River. Any interference in a stable natural system usually drives the system into instability. Every drop of water diverted from the natural system has an effect on all downstream society. Some of these effects such as flood control may be seen as good, but others such as reduction of stream flow, loss of needed water supplies, loss of wetlands, are not.

Recently, the State of Kansas successfully litigated against Colorado for taking water adjudicated to Kansas by compact from the Arkansas River. Agriculture in Colorado had grown at the expense of agriculture and municipal water supplies in Kansas. The United States Supreme Court decided the matter. Planning for the consequences of interference in natural systems is a basic requirement of any water policy.

The sustainable water question must resolve the issue of determining priority of water use. Competition for water resources is increasing and will increase between user groups as well as between nations, as global population continues its exponential growth. There are some clear choices to be made.

As cities expand, they demand more water, and the only resource left in many places, like southern California, is to take the water from agriculture. Water for direct human use takes precedence over water for indirect human use (agriculture, hydroelectric power generation) in the United States. However, there are costs associated with that precedence.

Colorado Springs and Denver have been purchasing water rights in the mountain valleys above them for a number of years. The land that was irrigated grass pasture no longer supports large-scale grazing or hay harvest, and many of the ranches that were dependent on the irrigated meadows have been subdivided into 35 acre "ranchettes" for urban recreational homes. Urban sprawl exacerbates urban water demands.

Agricultural use of water is very high. Over 83% of the water used in Kansas in 1995 was for irrigation, nearly 3.5 million acre feet (Gerhard, this volume). The green revolution that feeds large portions of the world requires massive amounts of water. As population grows, municipal water demand grows, water is diverted from agriculture, and agricultural productivity drops. Food supply can then become the problem. A sustainable water policy requires balancing of competing needs: for human consumption, industry, agriculture, and natural ecosystems.

Summary

In summary, there are sufficient fossil energy resources and other conventional fuels, as well as nuclear energy resources for the next few decades, despite an increasing global population. In the short-term, energy is sustainable.

Although oil and natural gas prices are high by modern standards, they are not high in a historical context. Some of the high oil price is in the products from petroleum rather than the crude supply. Refining capacity in America is working at nearly 97% of capacity, allowing for no safety margin. Whenever a major refinery must shut down for maintenance, supply of products drops below demand. Fewer refineries exist today (159) than 20 years ago (324). Capacity has been reduced by more than three million barrels per day (Gold, 2000). Transportation of large amounts of crude oil or petroleum products to the points of ultimate consumption by ship is becoming increasingly costly. Transportation margins appear to be thin enough to discourage investment in new capacity. These issues affect the energy supply outlook.

In the mid-term, out 50–100 years, there is concern that technological innovation will not keep pace with energy demand on a global basis. There is no consensus as to when the global petroleum supply will have peaked, although many, including Edwards (this volume), believe that it will occur in the next 50 years. With projected population of 10 billion by 2050, there is cause for concern.

Natural gas is a huge global resource, some of which is wasted by oil production in remote areas. As the resource gains value and desirability, more will be captured and transported to regions of high demand. The technology to capture and transport natural gas is constantly improving, and we can expect to see significantly more gas on the market by the time it is needed.

Unconventional resources and energy conservation will be required to maintain the flow of energy to the expanding population. Whether fuel cells and gas hydrates or tar sands and oil shale, there does not appear to be a good mid-term solution to the energy fuel mix other than greatly expanded use of nuclear energy. There appears to be a shortfall developing in sustainability of conventional energy resources in the mid-term.

A domestic and eventually an international energy policy is necessary by the United States to sustain the nation's energy supply. Without technological advances to increase energy supply, the remaining petroleum resources will be competitively sought, and it is extremely likely that wars will be fought over the remaining resources. There seems to be little hope that equity issues involving energy supply will be addressed during this period of potentially increasing conflict.

For the long term, there is no question that unconventional thinking and unconventional resources will be necessary to sustain the world's energy supply. If there is to be any equity in the distribution of energy and energy resources among the societies of the Earth, it must come through invention of cheap and transportable energy resources not now well-known.

Schmitt (this volume) has outlined one such approach. Lunar energy supplies perhaps could solve the energy sustainability problem for generations to come, but to develop the moon as an element of the energy supply for the Earth requires bold and creative approaches—thinking "outside the box." Political decisions must be made for time scales far longer than the months or years to the next election. We must do better than we have.

Setting priorities for water use to sustain freshwater supply will not be easy. Already, agriculture and natural ecosystems are in political conflict. Waterfowl and wildlife refuges are claiming water farmers consider necessary for irrigation. Minimum stream flows, federal regulations on "swimmable waters," wetlands preservation laws, and attempts at restoration of habitat to pre-development conditions have greatly increased water demand without any comparable increase in water supply. Restoration of the Florida Everglades is one such attempt (Scott and Schmidt, this volume).

A sustainable water policy means providing potable water in perpetuity, for whatever size global population materializes. While there is sufficient water on Earth to accomplish that goal, there is insufficient wealth among many nations who need more water for their people at places the water does not naturally occur in sufficient quantity or quality. Transporting water is very expensive and has many unintended consequences downstream from the diversion. Desalinization of ocean waters and pumping of deep fossil waters requires prodigious amounts of energy, further adding to costs and adding to energy demands.

One approach to developing a sound sustainable water policy is to value water appropriately, using the full cost approach. This requires that the consequences of diversion and of depletion be fully accounted for, and that the value of natural ecosystems, particularly watersheds and groundwater recharge areas be quantified along with agricultural, industrial, and municipal consumption. Since sustainable water is a local problem in a regional context, an integrated watershed/recharge planning system is required, rather than one limited by unnatural geopolitical boundaries.

There is sufficient potable water on earth for its inhabitants. Getting adequate quantities of appropriate quality water to the right places at the right time is the problem.

Intersection of Energy and Water Sustainability Issues: Epilog

Considering both sustainable energy and sustainable water as the joint conference topics was based on a belief that these two resources are very closely linked and are destined to be the commodities over which armed conflicts are likely during the remainder of this century. Water and energy sustain agriculture. We need energy to have water in today's world.

A case in point is the use of water from the High Plains Aquifer of western Kansas. The original water column exceeded 600 feet in parts of southwestern Kansas, but depletion by pumping for irrigation has dropped water levels more than 170 feet in specific locations, as natural recharge is slow and uncertain (Gerhard, this volume). Much of the water is considered to be fossil water, that is, water that was emplaced during the last glacial stage. Total depth to the base of the saturated zone is over 600 feet in some places and some wells now pump water up over 450 feet.

The energy to pump the water has come from natural gas, owing to the fortuitous overlap of the High Plains Aquifer and the Hugoton Natural Gas area, a world class giant gas field. Mineral owners in the region took their natural gas royalty in kind, accessing natural gas at the wellhead to operate their pumps. A prosperous farm economy was developed on this apparently free energy and free water. It operated well for 50 years, but reality has finally set in.

Increased natural gas production, rising because of increased demand has caused the natural gas reserves and field pressures to drop. Consequently, the wells are now on vacuum, and gas is routed to large compressor stations to be re-pressurized and put into the pipeline for eastern markets. Gas is no longer available to the farmer at the well head, and farmers have had to establish their own local gas utility to move sufficient gas from the large compressor stations back to run water pumps. At the same time, pumping energy requirements have soared, by virtue of the lowering of the water table, so that an additional 150 feet of lifting is necessary.

Farm prices have decreased, not increased, with time and inflation. There is serious question as to how long the irrigated agriculture of southwestern Kansas will survive, since dry land farming may not provide a livelihood for most of the farms.

There is linkage between energy and water. Moving water, desalinization, driving water treatment plants, all require large amounts of energy. If the cost of energy goes up, the cost of water will also. If the supply of energy goes down, the amount of water available for use where it is needed will also go down. Sustainable energy is required for sustainable water. The United States has had an energy and food policy for centuries: "Cheap food and cheap energy . . . at any cost."

This approach will be untenable through the 21st Century. A more realistic and informed public policy for water and energy is required. Earth scientists and life scientists must work together to bring about the necessary changes in public policy.

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Figure 1: Cost/richness diagram

Figure 2: Global population curve

Figure 3: Hydrologic cycle

Senator Pat Roberts' Advisory Committee on Science, Technology and the Future

Soon after being elected United States Senator, Pat Roberts recognized that science and technology would dominate economic, political and social policy in the twenty first century. To help him address policy issues in these areas, the Senator formed his Advisory Committee on Science, Technology and the Future, a group of Kansas's leaders whose purpose is to help the Senator strengthen the position of Kansas in the national agenda for science and technology. Since its formation in April 1997, the more than 100 members of the committee and its task forces have worked to:

- identify and promote opportunities and strategies for linking federal resources with the enhancement of science and technology in the state and in the region;
- foster collaboration and partnerships within the state to improve opportunities to secure federal resources for science and technology; and
- facilitate communication between the state's science and technology community and the Senator.

During their discussions, members of the committee discovered the importance of addressing science and technology issues at the state as well as federal level. The state needs to find the resources and develop the policies necessary to compete in the world marketplace increasingly dominated by technological innovations. Kansas must create successful niches in the new economy to assure a rising standard of living and high quality of life for all Kansans.

The Advisory Committee identified seven science and technology areas as strategic to the state's future. These are agriculture and the environment, aviation, biotechnology, energy, information technologies, manufacturing, and materials science. The following report summarizes the committee's findings and recommendations in these areas. It shows, for example, that the new economy will require technological changes in the state's traditional areas of strength – agriculture, aviation, energy, and manufacturing --- at the same time it will provide expanding opportunities to develop new strengths in biotechnology, information technology, and materials science. Most importantly, it suggests actions to help the state maintain and grow its share of the new economy.

Energy

The Challenge
Kansas today is the eighth largest oil and gas producer in the nation, and oil and gas represents an important export commodity and state governmental revenue resource. It contributes the equivalent to the state's economy of Kansas' combined crop production. Nonetheless, this important industry is troubled and may have passed its high water mark. While Kansas' gas industry remains comparatively stronger than oil, field pressures are diminishing in once robust areas. Record low prices for Kansas crude have been temporarily reversed by the price upswing orchestrated by OPEC's production curtailment. Today's price rebound does not signal a permanent trend toward higher producer prices. Instead, it underscores the power of foreign producers to control global supply (and therefore price) and highlights our nation's failure of energy independence.

Findings
To achieve sustainable energy independence represents an important economic and security challenge for the United States. As much as eleven billion barrels of oil remain locked in reservoirs lying beneath the Sunflower State, but it cannot be extracted by traditional means. Tax reform at the state level, development of new technologies, and increased expenditures in research at the federal level will be necessary to induce private sector investment, render production economic, and lead the U.S. toward energy independence. Kansas can play an important role in enhancing production of fossil fuels and in expanding horizons for the development and use of alternative energy supply resources.

Recommendation
Regardless of the success of new extraction efforts, it is clear that in time the oil and gas industry in Kansas will contribute less to the state's economy than it has in the past. As that industry ramps down in value, state leaders would be wise to develop counter-balancing policies that will maximize the potential value of alternative energy resources, such as wind energy, solar power, and the development of bio-engineered grasses that can make ethanol economic without reliance on politically controversial subsidies. Development of an alternative energy policy, working in parallel with policies that support oil and gas production, will support the emergence of exciting new energy industries in Kansas. Research is necessary to analyze potential impacts of alternative energy development. For instance, there has been no wind inventory of Kansas, as pointed out by the wind energy adherents at the public meeting of the Energy Task Force. Similarly, Kansas universities and scientists should be encouraged and supported in their efforts to understand the technical and economic issues surrounding non-traditional energy supply, from enhanced oil and gas production to biofuels and fuel cells. A national energy supply policy is necessary if any of these recommendations are to be implemented.

To create a focal point for Kansas' leadership in the development of new technologies and the emergence of alternative energy resources, state leaders should launch an all-out pursuit seeking designation of Kansas as home to the Mid-Continent Energy Research Center authorized by the 1992 Energy Policy Act.

Impact
Kansas can attract strong external funding for support of technology development and help lead the nation toward sustainable energy independence. Appropriate policies and enlightened public understanding of national energy needs and our energy potential can result in a future that is economically bright and that contributes to our national security. In so doing, Kansas can retain its position as a net energy exporting state.