

HUMANITY 3000

ENERGY CHALLENGES

THE NEXT THOUSAND YEARS

EXECUTIVE SUMMARY

BELLEVUE, WASHINGTON USA
MARCH 30 – APRIL 1, 2007



A FOUNDATION FOR THE FUTURE PUBLICATION



*“Energy Challenges: The Next Thousand Years”
Executive Summary*

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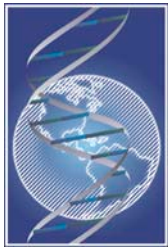
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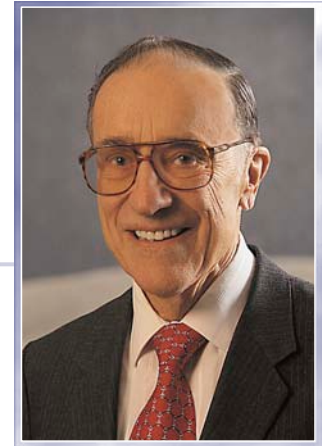
1. Future – humanity.
2. Millennium – Year 3000.
3. Energy.
 1. Title.

The goal in publishing the Executive Summary of the workshop “Energy Challenges: The Next Thousand Years” is to encourage humans to think about and act upon issues that the workshop participants deemed critical to the long-term future of energy and humanity.

Printed copies of this publication are available from the Foundation For the Future. Contact the Foundation for details.



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August 2007

Dear Readers:

This Executive Summary is intended to summarize the recommendations from our Humanity 3000 workshop “Energy Challenges: The Next Thousand Years,” held March 30–April 1, 2007. Prompted by the seriousness of the energy crisis and climate-change effects worldwide, the workshop emphasized tactics and strategies for the future. The comprehensive proceedings of the workshop will be published in full later this year.

The Foundation For the Future was established with the mission to increase and diffuse knowledge concerning the long-term future of humanity. Our Humanity 3000 Program focuses specifically on the thousand-year future, starting with the basic question: “Where does humanity go from here?” The March/April 2007 workshop posed that question in the context of energy in three time periods: (1) from now to the end of the present century, (2) over the next few centuries, and (3) over the next thousand years.

The Foundation invited energy experts from Europe and North America, and scholars concerned with the long-term future of humanity to come together to discuss renewable energy science and technologies anticipated to emerge during coming centuries. Sixteen participants, representing four countries, gathered to share their expertise.

I am pleased to present this Executive Summary of the “Energy Challenges” workshop and hope you will appreciate reading about the main issues and the recommendations that arose in the discussions about energy going forward in this millennium.

Sincerely,

Walter Kistler
Co-founder and President

“Energy Challenges: The Next Thousand Years”

Gustav R. Grob
Martin I. Hoffert



Feng Hsu
Fabrizio Pinto



Darel Preble
Thorsten Ludwig



John C. Mankins
Thomas F. Valone



Participants at Work



Crispin Tickell



Eric J. Chaisson



Howard Bloom



Russ George



Dennis M. Bushnell



Jerome C. Glenn



George E. Mueller



William H. Calvin

“Energy Challenges: The Next Thousand Years”

Sesh Velamoor, Facilitator, explains guidelines before the first panel makes presentations.

Right, Dennis Bushnell sums up the present energy picture.



Left, Walter Kistler speaks about coal with sequestration for the near term.

Howard Bloom reports to the plenary on the conclusions of Breakout Group 3.



Martin Hoffert, in a breakout group with Crispin Tickell, Darel Preble, George Mueller, and Russ George, outlines possibilities for energy a thousand years into the future.



Participants at Work



Gustav Grob presents an argument in a breakout group, attempting to convince (clockwise from right) John Mankins, Howard Bloom, Eric Chaisson, Thomas Valone, and filmmaker Jon Palfreman.

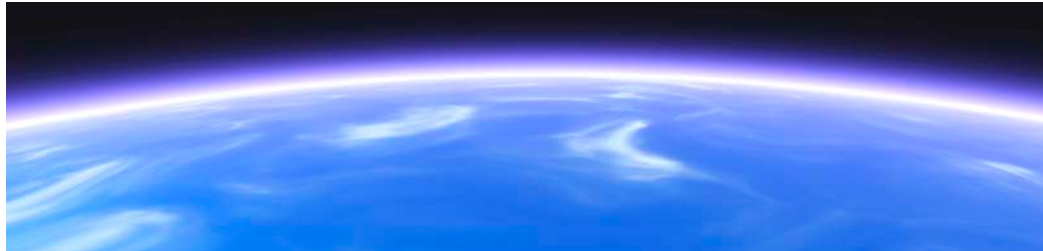


(Clockwise from left) Jerome Glenn, Feng Hsu, Thorsten Ludwig, Fabrizio Pinto, and Dennis Bushnell discuss proposed requirements of a global energy/ environmental tax system.



Fishbowl 1 debates the issue of energy system storage and distribution, facilitated by Sesh Velamoor. Participating are (clockwise from left) Fabrizio Pinto, Dennis Bushnell, George Mueller, William Calvin, and (speaking) John Mankins.

Contents



List of Participantsxi	
Section 1	Workshop Overview	1
	Introduction	1
	Purpose	2
	Process	2
	Goal	2
Section 2	Summary of Recommendations	3
	The Three Most Critical Issues	3
	Conclusions of Workshop Discussions	7
	Post-workshop Correspondence	8
Section 3	Main Issues	11
	Near-term Future (to Year 2100)	11
	Medium-term Future (the next few centuries)	17
	Far Future (to Year 3007)	20
Appendix A	Speaker Abstracts	23
Appendix B	Participant Statements	27
Appendix C	Participant Biographies	37

“ENERGY CHALLENGES: THE NEXT THOUSAND YEARS” EXECUTIVE SUMMARY

List of Participants



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Workshop Overview

1



Russ George and Fabrizio Pinto



Thorsten Ludwig urges personal responsibility and sensible decision-making.

INTRODUCTION

The Humanity 3000 workshop “Energy Challenges: The Next Thousand Years” was sponsored and conducted by the Foundation For the Future, Bellevue, Washington, March 30–April 1, 2007.

Sixteen energy experts from Europe and North America gathered for face-to-face discussions on the current state of energy on Planet Earth, renewable energy science, and technologies anticipated to emerge during coming centuries. The workshop was held at the Westin Bellevue Hotel in Bellevue, Washington USA. The primary intent was to elicit discussion and debate among the participants about all potential sources and technologies for energy production over three time frames: the rest of this century (near term), the next few centuries (medium term), and the next thousand years (long term).

Primary intent

Panels were convened to focus on each of the three time frames, with a total of 14 panel presentations. In addition, the workshop featured three keynote presentations:

Keynote presentations

Dr. Jerome C. Glenn, Director of the Millennium Project, Washington, DC, on “State of the Future: Energy.”



Sir Crispin Tickell, former British Ambassador and currently Director of the Policy Foresight Programme at the James Martin Institute for Science and Civilization, Oxford University, on “Energy Challenges: The Next Thousand Years.”



Dr. Gustav R. Grob, founder of the International Clean Energy Consortium, Zurich, Switzerland, on “Energy Technologies: Near, Medium, and Far Future.”



The Foundation’s goal is not to advocate any particular cause or position, but rather to create forums for scholarly discussions about the future and to distribute the results and records of those discussions widely in the anticipation that an informed, bottom-up process of choice and decision-making will affect the long-term future.

Under its mission to increase and diffuse knowledge concerning humanity’s long-term future, the Foundation For the Future launched its Humanity 3000 Program in 1998. The Program convenes workshops and seminars on an annual basis and a major international symposium every five years. The fundamental objective of the Humanity 3000 Program is

to bring together at regular intervals a changing roster of prominent thinkers from around the world in a multidisciplinary framework to discuss issues that are most likely to have a significant impact on the long-term future of humanity.



“Energy Challenges: The Next Thousand Years” followed five Humanity 3000 seminars; knowledge workshops on humanity and the biosphere, humans and space, nanotechnology, and the status of humanity’s search for extraterrestrial intelligence; and two bidecadal Humanity 3000 symposia. Proceedings of previous Humanity 3000 events may be downloaded from the Foundation’s website [www.futurefoundation.org]. Proceedings of the “Energy Challenges” workshop will be published in hard copy and available for download from the website in fall 2007.

PURPOSE

IPCC The Intergovernmental Panel on Climate Change (IPCC) has determined not only that climate change is a fact, but also that there is a very high probability that it is being caused by humans. The cause, of course, is the continuously increasing level of CO₂ introduced into the atmosphere by the burning of fossil fuels. Humanity’s current sources and uses of energy – mostly carbon-based fossil fuels – must be superseded. Most studies pertaining to the future of energy do not grapple beyond short-term (next 50 years) considerations of conventional and alternative energy sources.

Three time frames
Self-sufficient strategies

The Foundation For the Future workshop “Energy Challenges: The Next Thousand Years” was designed to consider all potential sources and technologies for energy production over three time frames: the near term (rest of this century), the medium term (next few centuries), and the longer term (thousand-year future), as well as the challenges facing humans on the planet in developing and implementing self-sufficient strategies for energy.

Sixteen prominent energy experts from around the world participated in the workshop to discuss renewable energy science and technologies anticipated to emerge during coming centuries.

PROCESS

PHASE 1: Participants’ self-introductions.

PHASE 2: Keynote addresses provide a long-term perspective on selected issues.

PHASE 3: Panel presentations and discussions, one panel for each of three time frames.

PHASE 4: Small-group discussions to identify critical issues for energy challenges.

PHASE 5: Three fishbowl groups discuss assessments of three most significant topics/questions/issues pertaining to energy challenges.

PHASE 6: Participants’ individual concluding statements.

GOAL

Identify issues that are deemed critical to the long-term future of humanity and energy as a result of the process described above.

Summary of Recommendations

2



Howard Bloom

Jerome C. Glenn

Dennis M. Bushnell

Russ George

THE THREE MOST CRITICAL ENERGY ISSUES

The workshop participants arrived at consensus on the three most critical issues related to energy for the long-term future. The three were: energy system storage and distribution, an international technical body to vet energy solutions, and changing public perception and awareness about energy solutions. Each of these issues became the central topic of a fishbowl discussion. Following are principal points brought forward in the fishbowl conversations:

1. Energy Systems: Storage and Distribution

Participants were asked to state the objective for energy, going forward, and four statements were offered: (1) To put into place affordable, carbon-neutral energy systems that can lead to substantial reductions in greenhouse gas emissions within 20 years. (2) To achieve 100 percent Green, efficient, affordable, scalable energy. (3) To turn around carbon emissions globally before 2020. (4) To find novel ways of large-scale power distribution that do not create concern in the public from a safety perspective.

Objective

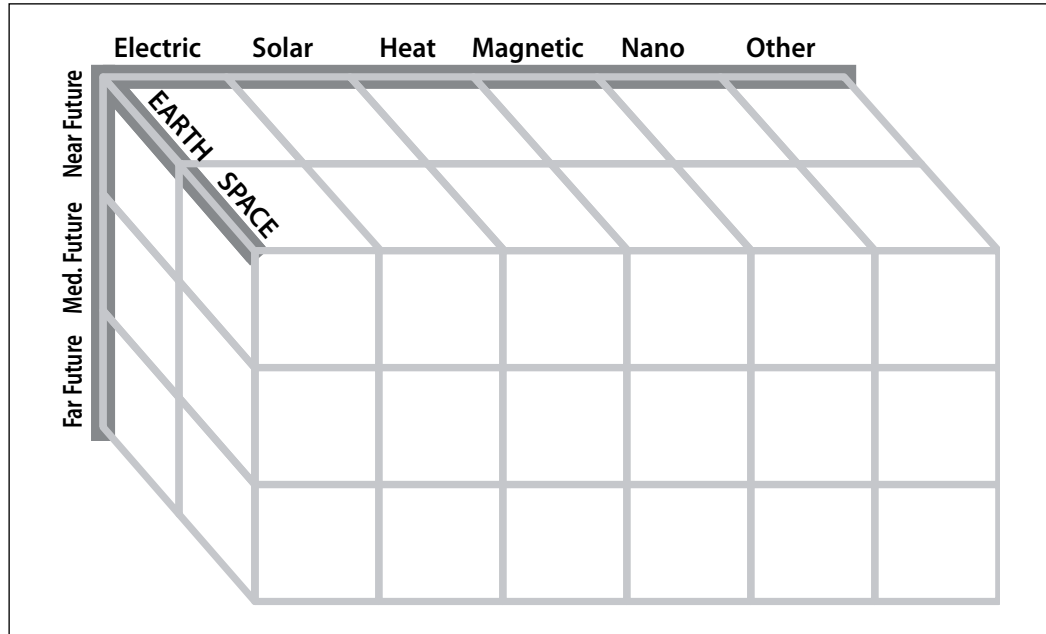
Within those objectives, requirements for storage and distribution will vary according to three matrices: (1) Time frame – energy technologies for the near-, medium-, and far-term future; (2) Scale – macro and micro; and (3) Energy type – electrical, heat, magnetic field, light, electromagnetic, etc. [See diagram next page.]

So long as there are clear objectives and a clear source of funding, human ingenuity has almost no limit as to what can be accomplished. However, the length of time available for the accomplishment will impose limits on what is feasible. Creativity will be an important component; as an example, batteries in electric cars could be utilized to provide storage for a whole system.

Nanotechnology will be an important component, going forward, in energy efficiencies. Much of the energy may become at ever-smaller scale, down to individual or residential scale. This will require smaller-scale storage. Decentralized power generation and distribution will ensure greater sustainability for the future than a centralized infrastructure.

Nanotechnology

Energy Storage & Distribution Matrix
(Sesh Velamoor)

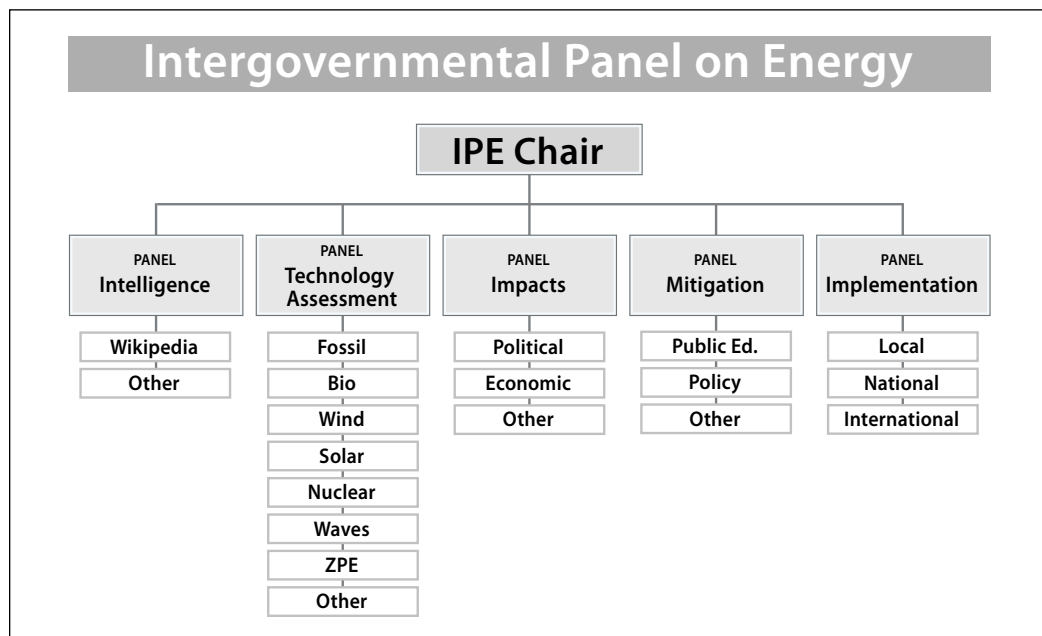


Solar power Each type of energy has its own challenges. For example, solar power has the inherent issue of how to store energy for use during nighttime hours. Among storage options are a solar concentrator to heat rock or other mass, with the energy tapped later via thermoelectrics; biofuels, especially algae biomass; artificial photosynthesis to produce CO that can be stored for nighttime use; flywheels; and eventually superconducting magnetic energy storage (SMES) with carbon nanotube magnets.

End uses Each of the three main end uses of energy – heating/cooling for buildings, the transportation sector, and electric power generation – has its own requirements for supply, storage, and distribution. Because of the complexity of the subject, energy system storage and distribution should be evaluated at a global systems level, and coming out of those analyses would be requirements leading to specific technologies.

2. An International Technical Body to Vet Energy Solutions

Precedent The fishbowl participants who focused on the need for an international technical body to vet energy solutions recommended that the precedent set by the Intergovernmental Panel on Climate Change would be useful to emulate. The specific characteristics of the IPCC to replicate are: (1) The structure of three working groups: one on the science, one on the social and economic impacts, and one on mitigation or recommended actions. (2) The groups are regarded as impartial; they report separately; and the reports are distributed all over the world. (3) There is a discipline of reports on a structured schedule.



*A Structure for the
“Future of Energy”
(Sesh Velamoor)*

The name “Intergovernmental Panel on Energy Technologies” (IPET) was suggested, though a subsequent recommendation was to delete the “T” and call it “Intergovernmental Panel on Energy” (IPE) because it should focus on all issues related to energy and not solely on the technologies. Funding of such a technical body might come from the governments composing the body, or possibly through an international social-consequence tax. Information disseminated by the body must be in all six UN languages, not solely in English. The above chart illustrates a structure that might be implemented for this technical body.

Other possibilities for an international technical body to vet energy solutions were also put forward. One was an Internet clearinghouse that would provide an exchange network to disseminate information but without a large, physically based bureaucracy. Second, a collective intelligence system on energy was suggested – one that can be updated as insights are achieved, rather than waiting for periodic reports, and with a place for input from anyone in the world. Accordingly, information from an IPCC type of organization would provide input to the collective system, as would Google, the UN, individuals, etc. A third alternative was a system of systems that would go beyond providing information on the pros and cons of different technology options; it would also establish criteria and standards, support the decision-making process with risk analysis, and provide an implementation structure for policies and recommendations.

Regardless of what sort of international body develops, there is a need in addition for a better way to organize the overall “community of interest” related to energy. It might be most relevant for such an organization to penetrate the IPCC Working Group 3 on mitigation in an effort to provide guidance on the revolutionary changes needed in global energy systems.

Intergovernmental Panel

Internet clearinghouse

Collective intelligence

System of systems

3. Changing Public Perception and Awareness about Energy Solutions

The “public” whose perception and awareness are matters of concern includes politicians and policy-makers, businesses and industry, tax-paying citizens – especially those who might be considered “nonscientific,” students, and children.

Key recommendations for changing public perception and awareness about energy solutions were the following:

- ▶ **Politicians** should be educated so that governments are encouraged to develop policies to stop the construction of coal-fired power plants. As an ongoing measure, there should be a Web venue where politicians and policy-makers can obtain instant, easily understood information on pros, cons, status, budgets, timelines, etc., on any energy technology. Politicians should be contacted and asked to incorporate into their campaigns an energy program designed along the lines of the Apollo Program of the 1960s for placing humans on the Moon.
- ▶ **Businesses and industry** must be encouraged not only to follow conservation practices but also to design energy-solution products. An example is the development of kits that could be purchased by consumers at stores like Home Depot, providing complete step-by-step instructions on how an individual can implement energy-saving or energy-generating devices and programs. Another example is the development of eco-friendly video games for children and students, e.g., with scenarios in which players use utilities in different ways and the player who uses the least energy wins. Builders should focus on development of entirely Green communities.
- ▶ **Schools** should offer energy-awareness courses to the nonscientific public, including students who will become tax-paying citizens in the next generation.
- ▶ **Individuals** can, right now, move toward energy-saving behaviors like turning off any lights not in use, buying hybrid cars rather than conventional cars, and no longer using incandescent light bulbs. Individuals should take steps to “offset their carbon footprint” by providing funds for such efforts as tree-planting and ocean iron-seeding. All individuals should be encouraged to “act Green; buy Green; build Green; vote Green.”
- ▶ In terms of **governmental participation**, though it may be preferable to implement changes in public perception and awareness through education and Web interface, it may be necessary to also enact rules, regulations, and laws to prohibit environmentally damaging behaviors.





*Darel Preble and
Gustav R. Grob*



*Feng Hsu and Howard
Bloom consider the
point Martin Hoffert
makes about the effect
of increased CO₂ in the
atmosphere.*

CONCLUSIONS OF WORKSHOP DISCUSSIONS

Main issues that arose in the workshop discussions are summarized in Section 3 of this document. In addition to descriptions of pros and cons of various energy technologies and discussion of related energy issues, the participants offered specific direction for the three time periods of the workshop; those recommendations are as follows:

The focus for the near term (through the end of the present century) must be in four areas simultaneously:

Near term

1. Commence and complete the move of society away from nonrenewable sources of energy. Coal-fired power plants must be stopped. Fuels for homes, industry, and transportation must be shifted to carbon-neutral, renewable energy. “Bridge technologies” that could be implemented for the transition from nonrenewable to carbon-neutral, renewable sources might reasonably be coal with sequestration and nuclear fission.
2. Make policy decisions that focus on promoting the development of renewable sources of energy that do not increase the amount of heat on the planet. That is, emphasize terrestrial solar and tidal energies.
3. Strongly promote conservation practices and technologies.
4. Purposefully pursue remediation of the carbon dioxide that has already been placed into the atmosphere and will continue to be emitted into the air until nonrenewable sources of energy are no longer utilized.



For the near term, a portfolio of energy solutions will be needed because no one technology has a guarantee of success and reliability. A global structure similar to the Intergovernmental Panel on Climate Change needs to be established to serve as a focal point for evaluation of the multitude of new, innovative technologies. This will yield effective investment, development, and implementation strategies.

The focus for the medium term (the next few centuries) will most likely emphasize space solar power, which will require low-cost space transportation, and utilization of nanotechnology and zero point energy.

Medium term

The focus for the far future (the next thousand years) will most likely emphasize energy from fusion captured directly from the Sun.

Far future

Thomas F. Valone

Darel Preble

George Mueller warned against the unintended consequences of focusing on one facet of energy distribution rather than the total system.



POST-WORKSHOP CORRESPONDENCE

Following the workshop, several of the participants continued the conversation via email exchanges, with one participant taking special note of the fact that the US Supreme Court declared on April 2, in a 5-to-4 vote, that CO₂ is a pollutant, a decision that may help drive to the forefront new energy technologies that will directly or indirectly reduce CO₂ pollution. Other comments and recommendations arising in this correspondence are summarized as follows:



Biomass

Seawater

Biomass in conjunction with seawater agriculture could help solve a number of issues for humanity, including energy issues. At present some 44 percent of land worldwide is considered “wasteland” because it is desert. At the same time, 97 percent of all water is seawater, which contains many important minerals including 80–85 percent of the nutrients required for plant growth. Further, there are over 10,000 natural halophyte plants (adapted for growing in saline conditions), many of which are potential staple crops and over 100 are being studied for commercial applications. Putting these points together leads to the suggestion of seawater irrigation of desert lands to raise halophyte plants. As an energy source, biomass is renewable and estimates are that biomass grown on less than the landmass of the Sahara Desert could replace the world’s current fossil energy requirements; biomass grown on approximately 6 percent of the US landmass could replace current oil and natural gas consumption. Energy costs of biomass production and processing are as much as an order of magnitude less than energy yields, which makes this energy source relatively inexpensive.

Such a plan could return for other human uses a high percentage of fresh water now used for conventional agriculture. Fuels produced from the biomass would be CO₂-neutral and viable alternatives to increasingly expensive petroleum. Due to costs of biomass transportation, bio-refineries should be distributed and scalable, with products largely deliverable via pipelines.

Space solar power

Disagreement remained among participants regarding space solar power, with opponents emphasizing the huge expense. Proponents were encouraged by an article from SPACE.com indicating that the Pentagon’s National Security Space Office may begin a study soon on the possibility of using satellites to collect solar energy for use on Earth.



Feng Hsu put forward the argument that terrestrial solar and space solar power technologies are not mutually exclusive; indeed, they complement one another. “Harnessing the inexhaustible yet harmless energy of the Sun should be a natural, logical, and most viable solution to eliminate our energy crisis,” wrote Dr. Hsu, “and such a paradigm shift of mankind from a ‘combustion economy’ to a ‘solar-electric economy’ is most imperative for the long-term, sustained (thus peaceful) human development.” Hsu emphasized that massive R&D efforts are needed and that essential technologies for taming solar energy resources, for both terrestrial and space applications, are carbon nanotube-based, organic plastic PV cells and energy-storage (battery) devices, which must be revolutionized in their efficiencies, cost, weight, and size.



A critically important issue introduced but not dealt with at length in the workshop was more thoroughly addressed in post-workshop correspondence. This is the problem of methane, specifically methane trapped naturally in the frozen Arctic tundra and at the bottom of the seas. Methane is some 20–22 times more potent a greenhouse gas than carbon dioxide, so the release of this gas into the atmosphere would significantly speed up the warming of the Earth. The near-term threat is that a temperature increase in the Arctic of even a few degrees – which appears certain to result from staying the course of present-rate increases in burning fossil fuels – will begin an unstoppable chain reaction of methane release.



Methane



Martin Hoffert provided an article he published in *Science* in November 2002. His observation then is only more accurate today: “Stabilizing climate is not easy. At the very least, it will require political will, targeted research and development, and international cooperation. Most of all, it requires the recognition that, although regulation can play a role, the fossil fuel greenhouse effect is an energy problem that cannot be simply regulated away.”



Dennis Bushnell identified *the* key issue with solving global warming as establishing the true nature of the problem in public consciousness: “Once the body politic has a grasp of what is at stake (including the methane-release nightmare), they will ‘go Green’ in dramatic ways, and industry and government will be forced to think differently ... Unless and until folks come to grips with *both* the seriousness and immediacy of the problem *and* the tremendous changes that will (affordably and actually quite quickly) be required, we will continue to simply ‘watch the ice melt.’” The recommendation is for a massive adult education program, on a worldwide basis, emphasizing four elements: (1) the consensus that atmospheric warming due to anthropogenic CO₂ release is real, (2) understanding of the equally serious second law of thermodynamics warming issue, which constrains what can be selected as solutions to atmospheric warming, (3) the methane problem, which could occur within decades, and (4) the need to move toward biomass fuels, in view of both the projections for oil price increases in less than a decade and the problems of imminent warming.

Public consciousness

Adult education

“ENERGY CHALLENGES: THE NEXT THOUSAND YEARS” EXECUTIVE SUMMARY

Main Issues

3



With Feng Hsu and Thorsten Ludwig, John Mankins emphasizes the need for a portfolio of energy technologies, rather than one solution. Crispin Tickell

NEAR-TERM, MEDIUM-TERM, AND LONG-RANGE FUTURE

Of the numerous energy solutions brought into the discussion during the workshop “Energy Challenges: The Next Thousand Years,” renewable and innovative technologies received the most attention of the participants, along with issues of objective evaluations of the plethora of innovative, new technologies, and energy storage and distribution. Effective conservation and CO₂ remediation strategies were also focal in the discussion. This section delineates pros and cons of potential energy solutions in the three time frames in the structure of the workshop: near-term future, medium-term future, and long-range future.

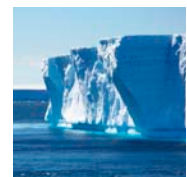
NEAR-TERM FUTURE (TO YEAR 2100)

The participants were in agreement that a collapse in nonrenewable energy sources will occur in the near-term future. Carbon-based energy sources, including coal, oil, gas, and nuclear, not only are significant causes of pollution and social cost that must be curtailed if the ecosystem is to be saved, but also are based on rapidly depleting resources. Carbon dioxide in the atmosphere is now at its highest level in 650,000 years and increasing by approximately 2 ppm per year. Humanity must undertake a massive move to carbon-neutral energy, phasing out technologies that emit carbon dioxide by the middle of the current century. Technologies endorsed to replace them must not further increase the equilibrium temperature on the planet. Heat is an unavoidable and significant by-product in the use of energy extracted from wood, coal, oil, gas, atoms, and any other nonrenewable sources. In fact, a key outcome of this workshop is the recognition of restrictions placed by the second law of thermodynamics on what is possible among the Green approaches to energy.

In the very short term, the nonrenewable energy sources must be addressed. Total energy anticipated to be produced on Planet Earth in the year 2012 is approximately 30 GW, with only 8 percent of it produced by Green technologies. The scientific consensus is that further global warming must be kept below 2 degrees Celsius to prevent irreversible melting of the Greenland and Antarctic ice sheets. Presently, thousands of coal-fired power



Carbon dioxide
Second law of thermodynamics



Global warming



Coal-fired power plants

plants spew carbon dioxide into the atmosphere, and more such power plants are planned, especially in the two largest coal-producing countries, the USA and China. Coal as a resource is not expected to be depleted for 500 years, but continued burning of coal will destroy the global environment long before the resource is used up. A near-term solution calls for all coal-fired power plants to stop burning the coal and instead utilize a coal-gasification process to convert the coal to Syngas (carbon monoxide and hydrogen), use the Syngas to power gas turbines, and separate out the carbon dioxide in the exhaust of the gas turbines for sequestration. Though sequestration is expensive, if such a revised route isn't followed, the coal-fired power plants now being built will significantly overwhelm emission-reduction levels set by the Kyoto Protocol. Coal with sequestration could be a short-term bridge in the move to carbon-neutral energy.



Energy demand
Apollo-like program

Participants were of two minds in regard to energy demand for the remainder of this century. World population is still rising. This is an issue at least until late-21st century, when it may level off at about 10 billion people, according to current UN/World Bank estimates; however, no one really knows the human carrying capacity of Planet Earth. Today, society's energy production increases at an annual rate of about 2 percent. Some participants felt that it is likely that humankind will need in this century tens of terawatts more energy, all of which must be carbon neutral; others felt that the greater efficiency and smaller size of devices will mean reduction in energy requirements. In any case, there was agreement that what is needed is an “Apollo-like” energy program – meaning, governmental commitment and policy support to the high degree of the 1960s Apollo Program that landed humans on the Moon and returned them safely to Earth – to determine what the superior technologies in fact are and how to implement them. This should be the political agenda.

Humanity must think differently about the entire energy issue. Market solutions must be implemented wherever possible, including incentives for the business community. The importance of governmental policy decisions can be illustrated by the law introduced to legislators in London that polluting vehicles must pay a very high toll to enter the city of London. Germany and other countries have been able to multiply renewable energies by passing laws that utility companies must buy renewable, produced energy, with stipulated cost guidelines.

Following are major discussion points regarding energy sources between now and the end of the current century.

Terrestrial Solar Power



Scalable
Intermittent

As an energy source, terrestrial solar power is achievable, unlimited, and is not harmful to human beings. Solar energy hits Earth's surface every day with clean energy that can be used without added heating, since it is already landing here naturally. In addition, solar energy is highly scalable: it can be scaled down to serve Third World countries and to operate in an individual household. If humanity can manage to utilize solar energy at a massive global scale, it can solve both economic imbalances and resources imbalances, while resolving the problem of greenhouse gases.

Offsetting those arguments in favor of terrestrial solar power is the fact that it is an intermittent source of energy, directly available only in daytime. For it to be viable as a key

energy source, there must be significant increases in conversion and storage efficiencies. Politically, the impact of the nuclear/fossil establishment lobbyists would have to be superseded with policies favoring and supporting solar technologies.

Integrated energy generation and use is already being tried in terms of individual households that have solar panels on the roof, gathering energy that is used for domestic purposes and to charge batteries in electric cars.

Currently less than one percent of the world's energy comes from solar power, due to photovoltaic (PV) costs and inefficiency. To power the whole of US electricity needs would require a field of solar panels the size of the state of Vermont. To satisfy world consumption would require about one percent of the land that is used presently for agriculture worldwide.

Wind Power

Wind power is obtained by converting wind energy into electricity or other useful forms by way of wind turbines. Wind is considered a useful Green source of energy but it is insufficient to meet energy needs, even when combined with other renewable sources. It is an intermittent source of energy, and storage is difficult. As energy demands become more reliant on renewable energy sources in the future, attention may be given to putting wind turbines in locations where winds most occur and building superconducting transmission lines to deliver the energy where needed. Consideration may also be given to the upper troposphere, where the jet stream is, as a source of wind energy.

Biofuels

Biofuels are fuels obtained from biological matter, also referred to as "biomass." Currently a great deal of attention is being given to raising crops, such as corn, for processing to fuel that will burn in place of nonrenewable fuels. Biofuels offer the advantage of easy storage and they can be used day and night. Though ethanol is only 20 percent energy efficient, other biofuels are as much as 80–90 percent energy efficient. However, there was concern among some participants about the fact that though biofuels burn clean, their production still yields carbon dioxide.

The participants did not agree about the efficacy of biofuels. Some had concerns that greatly enhanced bioenergy creation might destroy forest ecosystems and disrupt food supplies to make way for more fuel-rich renewable crops. There was even concern about whether biofuels would significantly ease the fuel problem. An article quoted from boston-herald.com reported: "If all the corn produced in America in 2005 were dedicated to ethanol production, it would reduce US demand for gasoline by, at most, 12 percent." "Reaching the US Administration's bioethanol goal of 20 percent would mean increasing corn production to 167 percent of 2005 levels and even then every grain would have to go into ethanol, which would significantly strain feed ingredients for chickens, pigs, cattle, and humans."

Other participants held that if biofuel production is done correctly, it need not compete with food production at all; that is, it could be done with algae and with seawater irrigation, neither of which would have an impact on corn production. In fact, if done correctly,



Storage efficiencies

Mass scale



Green source



Biomass



Efficacy

biomass by itself could provide an order of magnitude more energy than what humans worldwide are now using.

Hydropower: Hydroelectric, Tidal Currents, and Wave Power



Hydropower is a useful source of energy but insufficient to meet energy needs, even when combined with other renewable sources, though some European countries (for example, Norway) have moved to hydropower as the most prominent source of energy. In terms of the second law of thermodynamics, energy from tidal currents avoids the issue of adding heat to the planet. In fact, some participants concluded that *only* tidal and terrestrial solar energies avoid issues of warming the planet.

Complex scheduling

For most areas of the world, hydropower requires complex scheduling and at present drought is a significant problem.

Geothermal



Waste heat

In half of the world, drilling down two kilometers reaches rock at 200 degrees C. Either hot dry rock or hot springs could be used for geothermal energy. However, geothermal is insufficient by itself or in combination with other renewables to power the future world. Worse, use of geothermal entails bringing to the surface heat energy from deep under the surface. Some participants felt that geothermal would not heat the planet unnaturally, since it is already within the planet, but others held the view that geothermal would actually add to the heat at the surface, thus rendering geothermal unacceptable as an energy source. Adding further waste heat at the surface will further warm the planet and therefore contribute to global warming.

Nuclear Fission

Pebblebed reactors

Nuclear fission has the potential to energize our society indefinitely. For some participants, the possibility is promising of new fission technology, including the pebblebed reactors that don't use enriched uranium of the dangerous kind, and later fusion technology, using tritium and deuterium.



Negative side effects

However, nuclear energy is not “clean.” Nuclear wastes and threats of nuclear accidents are negative side effects, as are issues of nuclear fuel supplies and nuclear proliferation. “Nukephobia” greatly troubles the general populace and fission’s radioactive wastes are too dangerous. Security is a significant problem with any of the current nuclear power plants. Finally, fissionable U-235 is very limited and will be, like fossil fuel, used up in time.

Nuclear fission, like coal with carbon sequestration, might be usefully thought of as a bridge technology on the way to a more enduring, carbon-neutral source of energy.

Conservation

The more societies go to “tele-everything” – tele-commuting, tele-commerce, tele-medicine, tele-education, etc. – far less energy will be used, especially in connection with electronic cottages that can become energy independent. The ongoing IT/bio/nano/quantum energetics tech revolutions will facilitate serious conservation efforts; in fact, these revolutions alone could change everything related to energy in the near-term future.

A number of innovations that are ways to conserve or use minimal amounts of fuel were brought into the discussion. Carbon nanotube computing is expected to result in huge reductions in energy usage. At present 16 percent of the power on the grid goes to computing, and this percentage is estimated to increase to 60 percent by 2020 – but carbon nanotube computing will be a significant aid because it will offer three orders of magnitude reduction in electrical losses.

The Air Car not only is designed to operate on compressed air, but a hybrid now being developed places the compressor right on board. The prediction is that the hybrid will be able to drive across the whole country of Australia on one tank of gas.

Ultracapacitors are in development that will provide super-efficient ways of storing charge. These have the potential of replacing heavy batteries that have limited lifespan, providing instead the energy source in storage on board the electric vehicle that will last the life of the vehicle.

Nano-plastic photovoltaics can be used at one-tenth the cost of silicon photovoltaics, and if placed on roofs, it could generate 70–75 percent of the power on the grid.

A series of innovative inventions were mentioned that will draw heat from the environment in order to work. An example is the nanorefrigerator.

CO₂ Remediation

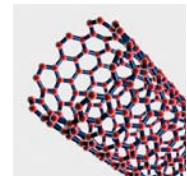
It is critically important to reduce the amount of CO₂ in the atmosphere. Iron seeding or dusting of the sea, now being done by Planktos, Inc. is an important remediation. Though a question was raised about the possibility that this process would increase the acidity of the oceans, another participant explained that chemically what the oceans are becoming is less alkaline, not dramatically more acidic.

Another approach is a new German process of artificial photosynthesis. This removes CO₂ from the atmosphere and produces a fuel (CO) from it.

A main issue currently is that the destruction of nature is free. A mechanism should be created by which anyone putting CO₂ into the air must pay fees for doing so. The suggestion was that money collected via such fees should go directly into projects that either take the CO₂ back out of the air or create energy in a clean way.



Tele-everything



Carbon nanotubes



Ultracapacitors

Iron seeding

Artificial photosynthesis

Fees

Energy Storage

The mismatch of supply and demand creates a major issue of storing and transmitting the energy. In fact, workshop participants identified this issue as one of the three most critical issues in energy. [See Section 2]



Solar concentrator
Nanovoids

Solar-electric conversion appears to be efficient and cost-effective, and can be completely decentralized for sustainability and self-sufficiency. Solar photovoltaics could be used to produce electricity during the daytime, with a solar concentrator for storage for nighttime use. The concentrator would heat rock or other material in an insulated container, then nighttime energy could be provided by direct solid-state thermoelectrics. Other effective options might be storing solar energy via a biomass algae component or SMES (superconducting magnetic energy storage) with carbon nanotubes, or using a new German-made process of catalyzed artificial photosynthesis that produces CO from atmospheric CO₂, and the CO can be used as fuel during nighttime hours. Current laboratory studies indicate that nanovoids, which bring in a nanotechnology advantage, may increase thermoelectric efficiency significantly. Fabrizio Pinto published an article in *Physical Review* showing how to store energy within a system that converts radiation into the zero point energy field and then later returns it – basically a battery on a molecular level [*Phys. Rev. B*, 60 (21), 1999, 14740–14755].



Efficient methods of storing and distributing energy will be required regardless of what energy generators are ultimately selected. There is a great need for improved battery technology. Already, advanced lithium-ion batteries can be produced in Asia at one-quarter the cost of batteries produced in the West. A possible means of storing energy in the future is nanotube batteries.



Battery technology
Hydrogen

It is critical to look at the magnitude of storage required. Batteries would not be adequate if the storage requirement is storing enough energy for several months of the operation of a country. A suggestion put forward for megastorage of electricity was to use SMES with carbon nanotube magnets (which are not yet available) to provide the structural strength to handle the magnetic field strengths. The result should be a battery, essentially, that has 10 to 20 times the storage density of chemical fuel. Another means for megastorage of electricity is flywheels, especially carbon nanotube flywheels, again, because of the greater strength.

One approach that is not recommended by the participants is storing energy by making hydrogen, for the reason that there is not a good way to store hydrogen. Though it is possible to store large quantities of hydrogen by making methane, methane itself is a very potent greenhouse gas. In fact, hydrogen was also discounted as having much of a future in energy in the near term because of not only problems of storage, but also the costs and inefficiencies involved in producing it and subsequently converting it into electricity.



Jerome C. Glenn, Feng Hsu, and Thorsten Ludwig.

Gustav R. Grob and Dennis M. Bushnell.

MEDIUM-TERM FUTURE (THE NEXT FEW CENTURIES)

Technologies for the next few centuries are those for which the science may be grasped today but the implementation and practical utilization are yet to be achieved. These are “real” technologies because they exist in the understanding of scientists and often in laboratory experiments, but their availability for application in the world will not occur until the medium-term future.

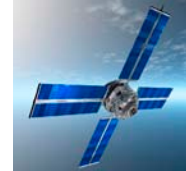
An important consideration for the medium term is that developing countries will continue to mature economically until “Third World” countries achieve equity with what are today considered the “developed” countries. The *per capita* energy flow will continue to rise with continued cultural evolution of the human species.

Space Solar Power

Unlike nonrenewable resources, particularly oil, the planet has billions of years of sunlight left. In space solar technology, sunlight is collected in space where collection is not limited to the “daytime” hours of a particular location on Earth. Power is “dispatchable”: with satellite stations, power can be distributed wherever it is needed, when it is needed. Though advances in space engineering and technologies are required, they appear tractable at this time.

Solar power satellites offer the cleanest source of virtually unlimited base load power, available 99 percent of the year at GSO. Other points in its favor are that undertaking the challenge would mobilize international energies and lead to advances in many space and terrestrial technologies, in addition to space solar power. It would also enable human economic expansion and settlement in space.

The leading argument against space solar power is the major economic issue of the cost of space access. To be economically viable, space solar power depends on something humanity doesn’t have yet: an inexpensive launch vehicle that is reusable. Though the solar array planned in the 1970s would have required a stupendous launch system as well as an in-space-assembly infrastructure, by the end of the 1990s, the need for in-space assembly had been eliminated and maintenance was robotic – but economics remained a roadblock. A key factor is payload weight, which may be mitigated significantly in the future by dry-weight carbon nanotube structures. If massive global-scale use of terrestrial solar energy can be promoted, there will be resulting R&D in photovoltaic wireless power transmission, which will lead to R&D in nano-based electric storage technology, which might lead to low-cost, reusable launch vehicles and robotic technology that will reduce the payload for solar power satellites.



Satellites



Cost

No agency is presently equipped to build space solar power, but a Congressionally chartered public/private corporation could do it, much as Comsat Corporation built communication satellites and another public/private corporation built the US trans-continental railroad.



Compared with terrestrial solar power, the competition comes down to either (1) low-cost launch plus the energy-conversion chain to get space solar power to Earth or (2) the efficiency of terrestrial solar power with the challenges of energy storage. Different participants had distinct preferences as to which was the better route to go. A major obstacle is present-day political policies that were developed to support fossil and nuclear energy. Second, this technology would involve deploying space-based arrays to redirect additional sunlight to Earth. This will cause the Earth's surface temperatures to rise – a rise owing to “thermal pollution” and not to any greenhouse gas, but still a rise in waste heat.

Though it may seem logical that space solar power would be ideal for electrifying, for example, villages in Africa that could not be reached by a terrestrial infrastructure, the economics will depend on scale. For a village of a couple of hundred people, it would be much more economical to use ground-based solar power. By contrast, a city of hundreds of thousands of people might require several hundred megawatts of energy, and at that scale, it becomes tractable to use space solar power with wireless power transmission.

Cold Fusion (Low Energy Nuclear Reactions [LENRs])

Prototype modules

To its proponents, cold fusion offers nonpolluting energy at low cost, using solid-state, low-temperature, nonradioactive nuclear reaction. As noted earlier, the science is already grasped. D2Fusion, a company represented by workshop participant Russ George, intends to develop and deliver its first prototype thermal modules for practical applications over the next few years. The device might end up looking like a modern dishwasher but would come with a lifetime of fuel on board to provide all of a household's heating and electricity needs. It is expected to cost about the same as a household furnace.



Though some participants consider cold fusion to be a safe source of abundant clean energy without radioactivity or nuclear waste, others consider cold fusion to be a “wild card” that must be avoided because of the problem of adding heat to the planet that is not here already naturally.

Aneutronic Fusion

Solving the long-term energy needs of populations on Earth and elsewhere could be achieved if humanity can fuse helium-3. An extra advantage is that it would produce a by-product of high-energy protons, which could, in turn, be used as a rocket propellant enabling velocities close to the speed of light. One of the problems in fusion of helium-3 is in getting more energy produced than the amount of energy expended in the effort.

Though helium-3 is available on Earth in relatively small quantities, there are significant quantities of it on the Moon. Studies have shown that it would be possible to mine it on the lunar surface, with equipment in humankind's present technical capability, but the processes of mining it, storing it, and bringing it to Earth are not currently feasible financially.

Another viewpoint was expressed that helium-3 is not needed to do aneutronic fusion. It is possible to do pB11 or H-B11 aneutronic fusion; it's not necessary to go to the Moon for helium-3.

Helium-3



Zero Point Energy

Though zero point energy (ZPE), as a physical entity, is real, the exact nature of it is a contentious issue. Though there is not yet any reproducible zero point energy production, there are several reasonable proposals to arrive at energy production. Space is not required; ZPE can be utilized terrestrially. This could be a very good resource in the long term, but funds need to be dedicated to studies to determine how much energy is there, how we can harness it and engineer it, and how we can use it. But there is more at stake than just extracting energy from the vacuum. This is a technology that must be understood, because without an understanding of zero point energy, there will not be nanotechnology. ZPE is at the foundation of quantum electrodynamics. On the nanoscale, these forces are the strongest forces that exist between neutral objects. In addition, there are areas in which quantum vacuum engineering or Casimir force engineering can contribute to efficiency. For example, nano-devices can have electricity stored in them that may be released through engineering of the Casimir force.

In 2006, the European Union decided to finance (€ 800,000) a project aiming to use the Casimir effect to move nano objects. Major European experiments at present include the flat-flat Casimir effect study in Grenoble, the Birmingham precision experiment to 0°K studying the cosmological constant problem, and a study in weight vacuum fluctuations in Italy. Additional studies are in progress in the United States.

ZPE is considered by many to be a "wild card." However, the workshop participants were reminded that in the history of technology, it has been the odd ideas that people allege aren't consistent with the laws of physics that end up completely revolutionizing society.

*Quantum
electrodynamics
Casimir force*

Martin I. Hoffert

Eric J. Chaisson

William H. Calvin

Howard Bloom



FAR FUTURE (TO YEAR 3007)

Among issues to consider for the very long term is that *per capita* energy flow rises with continued cultural evolution of the human species. Even after all countries considered now to be “developing” have reached equity with the rest of the world, it can be anticipated that *per capita* energy flow will continue rising and continue making demands on society’s energy budget as long as the human species continues.

Physics currently tells us that the sources of energy a thousand years into the future will be some form of solar energy and some form of fusion. However, there are likely to be tremendous energy implications in the resolution of current issues in physics regarding quantum and relativity, dark energy/dark matter, etc. Because energy will be an issue for the long term, there is a need for novel concepts and innovative ideas to have the opportunity to flourish.

Thermonuclear Fusion



Unobtainium

A hydrogen-based economy, with either energy from fusion that we master in our nuclear labs on Earth or energy from fusion captured directly from the Sun, was put forward as the very long-term solution to humanity’s energy demands. Neither method is imminent at present, and the previous efforts in Earth-based nuclear labs have only resulted in insurmountable difficulties. The Sun already produces energy by this means. In fact, the Sun pours onto the Earth about 10,000 times as much energy as all of civilization now uses.

On Earth, fusion has proved too dangerous because it produces intense radiation. Reactors would have to be built out of a substance one participant called “unobtainium,” a material that resists neutron radiation damage – a material that has yet to be discovered.

One reason the Sun is more efficient in fusion than are efforts in Earth-bound laboratories is that the forces of gravity on the Sun are sufficient to overcome the forces of separating the hydrogen. Humanity might be best served by abandoning nuclear efforts on Earth and investing instead in a major solar-energy research and development program.

Macro and Micro Energy Generation

The issue of major energy systems, such as today's grids, versus micro energy generation will likely be an important issue in the far future. If the world has a smaller population or a more dispersed population or population groups that wish to be independent, there will likely be more interest in micro systems rather than in large and vulnerable grid systems. Micro systems are those in which a village or a community or even a household could generate its own energy and reduce its dependence upon others. The energy of the future may be distributed endpoint production. The simplest forms of fusion now under study effectively in laboratories around the world deliver distributed energy at the point of use.

However, if humanity continues to be an urban-dwelling species, living in large groups, then a compelling issue may be some uninterruptible base load power that will accommodate terawatts of carbon-neutral power.

*Distributed endpoint
production*



“ENERGY CHALLENGES: THE NEXT THOUSAND YEARS” EXECUTIVE SUMMARY

Appendix A: Speaker Abstracts

KEYNOTE ABSTRACT



Crispin Tickell

“Energy Challenges: The Next Thousand Years”

ABSTRACT: Paradoxically it may be easier to look forward a thousand years rather than the next twenty. On the hopeful assumption that our species still exists, our descendants, in whatever genetic form, will have had to survive combinations of natural as well as human-made disasters, and come to different and more friendly terms with the natural environment. There is never going to be a shortage of energy to drive what is likely to be a much smaller, more dispersed, and electronically linked society. Instead of using up ancient reserves of stored sunlight, they will be using energy derived from a variety of sources, including some directly from the Sun, others from heat from within the Earth, others from the movement of tides, and others from crops cultivated for the purpose. In their own interest, they will practice an ethical system in which the natural world has value not only for human welfare but also for and in itself.

PANELIST ABSTRACTS



Dennis M. Bushnell

“Space and Energy – Sources, Observations, Mitigations and Limitations”

ABSTRACT: Brief discusses potential space-based energy sources, use of space observations for energy effects monitoring, a space-based warming mitigation approach, and the ultimate space-derived limit to anthropogenic energy utilization. In general, except for solar emanations, space-based energy generation and sourcing does not appear to be competitive with terrestrial sources/applications. Earth-observing space-based sensors are essential to sorting out both the anthropogenic effects of energy use on climate and the efficacy of the various remedial approaches. A comparison of the extensive arsenal of “post-petroleum energy sources” with space-based capabilities indicates that space is essential in two energy arenas going forward: solar emanations utilized via multitudinous technologies and space-based observing capability to enable/ensure climate remediation.



Martin I. Hoffert

“Bio-Geo-Chemical (BGC) Energy & Beyond”

ABSTRACT: High-technology civilization on Earth presently runs at a burn rate of ~15 thermal terawatts. Enabling a global population of 10 billion *Homo sapiens* to live Western lifestyles, while simultaneously avoiding fossil fuel greenhouse-induced polar cap melting and massive inundation of continental areas, will require generating 50 to 100 terawatts (TW) of carbon-neutral primary power by midcentury and beyond, or the equivalent, or combination with “negawatts” from ultra-energy-efficient generating and end-use technologies. The usual bio-geo-chemical suspects for humankind’s power supply – biofuels, geothermal, and chemical energy stored from prior geologic eras (fossil fuels) – are all inadequate for the job on millennial timescales. Photosynthesis cannot provide more than a few TW without devastating land available, land better used for human agriculture, biodiversity, and forestry. Likewise geothermal heat flux from residual radioactivity and core heat cannot generate more than a few TW unless hot dry rock heat is mined at rates high enough to impact plate tectonics. Oil and gas resources will be effectively gone by the end of the 21st century. Coal, from which liquid hydrocarbon fuels can be made, would be the default solution for this century were it not for potentially catastrophic global warming driving a melting planet. Coal is still the most ready for prime time primary power source in the BGC sphere but will require a massive shift to integrated combined-cycle central power plants making hydrogen and electricity with CO₂ capture and storage underground in deep saline aquifers, or similar, to address carbon-neutral energy needs – the goal of the US DoE FutureGen program. BGC technologies can be useful bridges to a sustainable planetary civilization so long as we begin now to create an appropriate technological infrastructure for the other end of the bridge. Long-term solutions for human energy needs on a thousand-year scale include terrestrial and space-based solar power, including advanced wind and electrical power transmission and storage technologies; carbon-neutral transportation options (possibly with hydrogen as an energy carrier); fission reactors with fuel bred from U-238 and thorium and/or fusion of deuterium from seawater and tritium bred from lithium or helium-three fusion reactor fuel from the lunar surface or gas giant planetary atmospheres. Broad-spectrum Apollo-like programs aimed at developing these energy options in time are proposed as concrete political objectives for the next US presidential election.



Walter P. Kistler

“A Very Large Potential Clean Energy Source”

ABSTRACT: The threat of global warming is increasing. Environmentalists try to fight this threat by relying on wind and solar energy. However, power companies who have to satisfy their customers’ needs plan to build hundreds of new coal-fired plants in China, India, and the United States, which will release more than 10 gigatons of CO₂ into our planet’s atmosphere every year.

It is possible today to build perfectly clean coal-fired power plants based on proven technology, where pollutants including CO₂ can be easily removed.

This presentation recommends that the presently planned coal-fired power plants be based on the new technology or pay heavy fines in proportion to their CO₂ emissions.



Thorsten Ludwig

“Zero Point Energy (ZPE) and Innovative Energy Technology: Current Research and Development in the Field of ZPE and New Energy Technology”

CONTENT: The short presentation will cover the introduction and history of zero point energy, the current experimental efforts to explore the Casimir effect and to determine the energy density of space. It will furthermore link ZPE with interesting new energy technologies and give an outlook to future possibilities and what needs to be done to make them reality.

ABSTRACT: Part of the modern quantum field theory is the concept of a short-lived energy quanta, called zero point energy, that form a random radiation background in which all other quanta like photons and particles exist and with whom they interact.

Zero point energy was first formulated in 1912 by Planck himself to solve last difficulties in the black body radiation formula presented in 1900 in Berlin. The idea of statistical energy that is still present at zero Kelvin (absolute zero temperature) was discussed by Nernst in 1916 out of theoretical considerations.

The fact that matter behaves like wave and particle at the same time gives rise to a ZPE and, in other words, to a fuzzy energy ground state. This fact is closely related to the Heisenberg uncertainty principle. The quantisation of space leads to the modern concept of ZPE as a radiation field, which was developed in the 1950s to understand the energy shifts in hydrogen spectra and the results of high energy collisions.

In 1948 Hendrik Casimir, a Dutch physicist, formulated the effect named after him. The Casimir

effect postulates that the restriction of electromagnetic waves in space by metal plates gives rise to a difference in ZPE and leads to force on the plates. Since the 1950s the effect has been measured and confirmed many times, giving us more information about the nature of ZPE.

Recently with the fast development of micro and nano devices, the study of this effect has greatly increased. Since the Casimir effect is one of the easiest methods to measure ZPE, the effect is currently studied to solve the great question: How large is the energy density of space (vacuum)? This is a very fundamental question and there is currently a high interest from several fields of physics to get a quantitative answer.

With the Casimir effect it is easy to show that the ZPE can be converted into usable macroscopic energy. Therefore ZPE can be used to do work. There is a European Union-funded project called NANO-CASE, which aims to use the Casimir effect to move nano objects. In the United States, Jordan MacLay and Fabrizio Pinto are doing excellent work to create practical ZPE devices.

A number of new innovative energy technologies can be related to the use of ZPE. These technologies include a wall drying system with no (conventional) energy input, magnetic motors, and plasma technologies – especially excess energy related to discharges has been reported by several researchers.



John C. Mankins

“Space Solar Power: Reaching Realism – How We Might Realize Abundant and Affordable Energy from Space in the Next 20 Years”

ABSTRACT: During the coming century, truly vast amounts of carbon-neutral energy will be needed to meet the concurrent challenges of increasing the global *per capita* quality of life AND stabilizing greenhouse gases in the Earth’s atmosphere to some manageable level. Given the technologies now in use to sustain the current world economy, these thousands of terawatt-hours of new energy must come in the form of both electrical power and a variety of fuels. Although this energy will come from various sources, space solar power is one of the more important options for safe, affordable, and abundant energy on this scale.

However, any shift from one suite of large-scale, infrastructure-intensive technologies to another can take decades to realize. Examples have included the transitions from water-borne transport to rail-carried transport of freight, from wood to coal, and others. All of these major technological transitions have

required “local” economic feasibility to be realized, including both locality in time and space (payback within a few years to a decade, with revenues drawn within some relatively predictable economic setting). In other words, the decision to make the transition must somehow be rational – it must make sense for individual decision-makers. Almost certainly, the same must be true for space solar power.

The key to “locally rational” decisions that lead to space solar power is threefold. First, the technologies to be developed must have applications that are nearer term and multi-faceted. Second, interim systems must be possible that provide value to decision-makers/investors within both government and industry. And finally, space solar power pilot plants must be possible that are affordable, have value, and retire risks – while providing legitimate energy services.

This presentation will explore these questions, focusing on the potential pathways by which affordable and abundant space solar power may be realizable.



Darel Preble

“The Clean and Natural Baseload Energy Solution – Space Solar Power”

ABSTRACT: Space Solar Power (SSP) – no other energy alternative so fully, cleanly, and directly addresses so many of our complex and intractable problems:

1. Declining global oil production accompanied by rising energy, food, and material prices
2. Nuclear proliferation
3. Energy security
4. Declining nutrition in our food
5. Escalating climate change distress

SSP would revitalize America by showing that a multitude of space-development-related educational fields, from telerobotics to wireless power transfer and environmental sciences, are vitally relevant to these great problems. Better jobs would be created for a brighter tomorrow as civilization expands. Choosing to charter an SSP corporation would be “a small step for man, a giant leap for mankind.”



Crispin Tickell

“Energy in the New Future”

ABSTRACT: We are beginning the painful process of moving from a high carbon to a low carbon society. The impacts affect the organization and management of society, particularly cities, as well as the values and behavior of individuals in their daily lives. We need to think differently across the spectrum.



Thomas F. Valone

“Future Energy Technologies”

ABSTRACT: With the decline in climate quality and as fossil fuel usage in the 21st century unfolds, the discovery and development of fuel-free energy sources is mandatory for humanity’s survival. More unconventional energy technologies are emerging that offer hope for future energy, which is the subject of this presentation.

Appendix B: Participant Statements

Prior to the workshop, the participants were asked to provide written responses to the following question:

What are the three most critical issues pertaining to humanity and energy challenges?



Howard Bloom

1. Energy independence for America.

We have to escape the geopolitical prison whose bars are made of oil. The immediate available solutions? Terrestrial solar and wind power, biofuels, cellulosic ethanol, and space solar power.

2. Change our perception of resources.

Resources are endless. Every form of toxin, garbage, waste, and excrement is a resource waiting to be discovered. When in doubt, follow the lessons of bacteria. These research-and-development masters are milking energy from the sulfur and heat of undersea vents and are turning granite into food two miles below your feet.

3. Do our evolutionary duty and carry the experiment of life – the DNA and cell system – to new homes, homes in orbit, homes on bodies like the Moon and Mars, and ultimately homes on the bodies of planets circling other stars.

What does this have to do with energy? Everything. Solar power in space is endless. And even spouts thousands of light-years long erupting from black holes are energy sources waiting to be harvested on behalf of ecosystems, the family of DNA, and that family's most recent achievement – consciousness.



Dennis M. Bushnell

Stop/reverse use of fossil carbon, necessity greatly exacerbated by CO₂ warming-engendered release of fossil methane from oceans and arctic. Possibility-to-probability for major tipping point. The several massive methane releases in the past resulted in some 80% species extinctions.

There is a surfeit of post-petroleum non-fossil carbon energetics options including seawater irrigation of halophytes on wastelands for energy, warming, land, water and food, drilled geothermal [viable on vast portions of the land-masses], nano plastic PV, genomic biologics for H₂ production via photosynthesis, tidal current turbines in the northern latitudes, LENRs

and possibly P-B₁₁ aneutronic fusion. These need to be developed and applied quickly and vigorously.

For the longer term the energetics issue is the second law of thermodynamics production of waste heat and the finite capacity of the planet to radiate such heat away from the planet. We appear to be some few orders of magnitude from planet warming from this mechanism. Eventually we will have to impose limits upon individual waste heat production, achieved either via conservation or usage limitations or population control. The planet is simply a finite resource.



Eric J. Chaisson

Evolution, Energy, Ethics

The *three Es* are chief among the most critical factors facing humanity during the 21st century and throughout the millennium beyond.

1. Evolution

Humans are part of an evolutionary universe. We, among all life forms, share a common ancestry with the galaxies, stars, and planets, each of these changing structures (including us) being open, non-equilibrium, thermodynamic systems. A good understanding of our cosmic roots, and a detailed knowledge of how all life relates to everything else, will help us create a wise, viable future course.

The unifying scenario of cosmic evolution now grants us an opportunity to embrace a modern, interdisciplinary worldview that people of all cultures can adopt – a big-bang-to-humankind story that traces developmental and generational change ranging from quarks to quasars, from microbes to minds.

2. Energy

Arguably, all ordering and organization in the universe depends on energy flow. Much like giant stars or microbial life, today's civilization runs on energy, in fact increasing amounts of it per unit mass for increasingly complex systems.

There seems no way to avoid the need for more energy. Rising energy *densities* are probably required for sentient beings to continue populating Earth indefinitely into the future. However, a central problem is not that we shall have too little energy. Rather, at some time within the next thousand years, we shall likely be self-producing too much energy. An inevitable by-product of advanced civilizations is heat loss, which will eventually rise to levels comparable to solar energy reaching Earth naturally.

3. Ethics

The next great evolutionary leap forward could be labeled “ethical evolution” – the espousal and creation of a global culture, where planetary citizenship becomes key to our survival on Earth. This will also likely require graduation beyond a Type-I civilization – namely, one that stops raping its own planet and begins utilizing the resources of its parent star, in our case the Sun.

The current trajectory of our society displays sensitivity toward the needed ethics, as exemplified by enhanced awareness of the need for human rights, environmental progress, global security, and energy policy. But is there enough time to embrace the needed ethics before an array of global problems makes sentient life on Earth improbable?



Russ George

1. *What are the threats to the survival of humanity?*

The single most immediate threat to survival of life on this blue planet is the crisis of ocean ecosystem collapse which is now close to – if not already over – the proverbial tipping point. While this crisis is linked to the “cause celeb” crisis of global warming in that it results from the impact of anthropogenic CO₂ it is a far more clear and present danger. Anthropogenic (fossil derived) CO₂ acts on the ocean ecosystem through three channels. Its most ominous effect is through its first-principals chemical effect whereby atmospheric CO₂ is dissolving into the surface ocean in a process that has produced a 10% increase of acidity in the past few decades. The chemistry is simply H₂O+CO₂→H₂CO₃, the weak acid known as carbonic acid, which we all enjoy in our carbonated beverages. It is a straightforward process: the higher the concentration of CO₂ in the atmosphere, the higher the ocean acidity – an environmental fact where we observe that the mathematical prediction exactly matches the measured effect. Unfortunately a major portion of the ocean food chain depends on the ability of the shell-forming phyto-plankton (like the diatoms) whose ability to precipitate their protective carbonate shells is rapidly diminishing due to enhanced solubility of those hard carbonates in the increasingly acidic surface ocean. Reports of the UK Royal Society in 2005 describe a crisis of acidity resulting in dramatic declines, if not total extinction, of this critical bottom-of-the-food-chain group of ocean plant life beginning by 2050. Just how important are these ocean plants? ... if you are an ocean scientist and you aspire to win your field’s Nobel Prize, you aspire to win the Bigelow Medal. Bigelow’s most famous quote was, “All fish is diatoms.” All diatoms are

seemingly now doomed to dissolve in our acidifying oceans and with them all higher life in the oceans.

The second-level effect of high and rising CO₂ on the oceans comes from its role in supporting green plants in terrestrial habitats. Today and for the foreseeable future our high atmospheric CO₂ is greatly enhancing the growth of dry land grasses, which in turn serve as the primary ground cover in regions of the world where dust blows off the land. That dust in the wind, while being valuable topsoil on land, is even more valuable as the main source of micronutrients to the pelagic ocean ecosystems. As high CO₂ provides a means for dry land grasses to obtain the CO₂ they need at a deep discount in terms of the H₂O they ordinarily trade to get it, they remain greener for a few weeks longer each year and cover the ground better, reducing the critical dust-borne nutrients from reaching the oceans. As a result the oceans are in dramatic decline in terms of net primary productivity. The declines are apocalyptic in scale, already 50% down in the sub-tropical and tropical ocean, 26% in the North Pacific, and 17% in the North Atlantic.

The third ocean impact comes from the global ocean warming that tracks with global warming as a whole. As the ocean warms due to its interface with the warming atmosphere, the surface ocean becomes more stratified and separated from the cold nutrient-rich ocean depths. This stratification results in an additional feedback mechanism accelerating the diminishment of ocean productivity.

2. *What are the opportunities that offset/mitigate the threats?*

The oceans in their massive volume have for all time served as a buffer for life on the planet. This buffering capacity is presently greatly diminished by the rapidity of the impact of the fossil fuel age. Today some 6-8 billion tonnes of net excess CO₂ is accumulating in the global atmosphere, the majority of which ends up as dissolved CO₂ (carbonic acid) in the surface ocean. The single means by which we might effect this perturbation is through ecorestoration of the ocean ecosystem of green plants. Fortunately Mother Nature has provided the means to our ocean and planetary salvation in the form of the stunning potency of the ocean phyto-plankton to bloom and, through photosynthesis, biologically fix much of the excess CO₂ into healthy, living, green, ocean plant life. Our unintended consequence of impeding the natural dust fall on the oceans can be reversed through simply returning that dust to the oceans. The key micronutrient in that dust is in the form of hematite iron oxides, simple iron ore, that has the potency, when incorporated into the chlorophyll molecule, to enhance productivity by a factor of 100,000:1. In simple terms we have an anthropogenic CO₂ problem

in our atmosphere of some billions of tonnes of CO₂ each year ... the ocean plants with supplemental iron can fix that CO₂ into healthy, living ecosystems such that for every tonne of iron, 100,000 tonnes of CO₂ are converted from the atmosphere and ocean harmful forms into plant life. The math is simple: a billion tonnes is a 9-digit number; iron is a 5-digit mitigation nutritional supplement. We have denied the oceans this iron-rich dust; let's give it back. For each billion tonnes of excess CO₂ in the atmosphere we need to deliver a mere 10,000 tonnes of iron to ocean plants. This is why the famous ocean scientist John Martin made his famous quip in 1989 addressing concern over global warming: "Give me a half a shipload of iron; I'll give you another ice age."

Planktos Inc. is a public company engaged in developing and delivering the iron solution to ocean collapse and global warming. Our research ships are now at sea engaged in the largest and most important experiments between man and nature ever conceived. Our intent is to conduct a series of large-scale ocean ecorestoration pilot projects over the next two years to determine if we can indeed apply a patch to our ocean operating system that will prevent a full ecosystem re-boot and a return of this planet to the roots of evolution that began some 600 million years ago. If we are successful, perhaps we will have the time to reconsider the wisdom behind converting vast geologic reserves of fossil carbon into toxic CO₂ before the obvious but unintended consequence prevails.

3. What are the emergent priorities to ensure the future well-being of humanity?

Humanity and all other forms of higher life on this planet began with the evolution of oceanic green plants some 600 million years ago, which transformed the primordial bacterial ocean/earth into one rich in oxygen. Since that beginning, the oceans have been the primary net producer of oxygen for this blue planet and that oxygen-rich environment provided the means for the evolution of animal life including humanity. Today some of us note with horror that the greatest mass extinction in this planet's geologic history is now underway with the re-boot of the ocean ecosystem from a green plant-dominated system to a bacterial system.

Humanity faces many priorities but in the scheme of things on this blue planet, we must understand that our penchant for unimpeded development and modification of the planetary environment has immediate consequences far beyond the scope of mere human life.

The claxon is ringing ... it is calling for "all hands on deck."



Gustav R. Grob

1. Are fuels indispensable for modern civilization and culture?

In ancient high cultures only four types of energies were indispensable: (1) Wind energy for sailing, water pumping, milling, and drying cloth. (2) Solar energy for growing crops and drying fruits, meats, and fish. (3) Muscle energy from humans and animals for moving and farming. (4) Fuel wood for cooking and heating in colder climes and seasons.

After the discovery of coal, petroleum, mineral gas, and uranium, man got dependent on these finite, hazardous fuels as predominant energy sources. They allowed easy long-distance travel, industrial mass production, and electrification as long as these fuels were available at reasonable cost for easy, but relatively inefficient thermal power generation.

The environmental and health consequences from the use of such fuels were disastrous. Global warming from fossil fuel emissions was beating all historic atmosphere temperature records in absolute terms and as regards acceleration to historic records, causing sea level rise, pristine ice melting, weather disasters, and loss of arable land. Health was affected by pollution and noise. Loss of fertility was another consequence of nuclear fuels and chemical proliferation. Oil wars killed millions of humans and wasted trillions of taxpayers' monies.

2. Why is the modern fuel age soon coming to an end?

Due to depletion of all mineral resources, man is forced to revert to renewable energy with the extra benefit that humanity is becoming independent of fatal political gambles and from imports ruining whole economies, especially of poorer nations – and the biosphere may find its natural balance and cycles again with fewer health hazards and more labour-intensive economies, instead of the finite, resources-squandering, crisis and warlord economies.

3. How is the transition to the clean, sustainable energy age possible?

Clean, renewable energies are so abundant and economical that all fossil fuel-fired power plants can be scrapped – the sooner the better. All transportation of the future will be by power trains with ZERO emissions and low noise. All internal combustion engines will end up in technical museums. Electric mobility will substitute liquid and gaseous fuel mobility.

Electricity will be the main energy carrier for individual and public ground transportation, for households and industry, complemented by the use of solar and geothermal energy for heating and cooling, generated by benign renewable energy like solar, wind, and hydro.

Millions of new clean and safe jobs will be created with this ultimate energy concept. All nations will become independent from imported fuels. New high cultures will emerge from this independence from speculative, polluting fuel sources. The waters will no longer suffer from oil spillages. Faunas and floras will recover from chemicals and extreme weather conditions. *The quality of life will become like in the Garden of Eden without wars.*



Martin I. Hoffert

1. SCIENTIFIC WORLDVIEW – Neural scientists strive to understand how rational problem solving can coexist with authoritarian belief systems and emotional baggage hard-wired in *Homo sapiens* genetically long before the agricultural, scientific, and technological revolutions. More adapted perhaps to hunter-gathering on African savannas, we’re challenged by the climate and energy problems of a high-tech world very different from the one we evolved in. Without reliable instincts to guide us, the human experiment must go forward by solving complex technological problems or risk collapse. Dark ages happen. In the face of an evident predisposition to dogmatic beliefs and consumerism, science as a way of understanding the world is our best hope. Today’s rampant scientific illiteracy couldn’t come at a worse time. We’re working on the wrong problems and fighting the wrong wars. The challenge is to overcome our genetic heritage enough to create a sustainable high-tech civilization on Earth; and eventually – my personal vision – to bring the spark of self-awareness to the stars.

2. SUSTAINABLE ENERGY – Today’s global economy is powered mainly by CO₂-emitting fossil fuels at rates projected to triple by midcentury if present 3%/year global GDP growth continues. Energy use grows 2%/year even if energy per unit GDP (a measure of energy efficiency improvements and economic sector shifts) continues its 1%/year decline. It’s already too late to prevent many adverse impacts of global warming. Still doable is limiting global warming to less than 2 degrees Celsius to prevent Greenland and Antarctic icecap breakup, requiring carbon-neutral power and/or efficiency “negawatts” equivalent to 100–300% of current energy use by 2050. This is a Herculean engineering job. Fossil fuels formed over hundreds of millions of years are burning a million times faster, with oil and gas production peaking in a few decades (or now) and petering-out by 2100. Relatively abundant coal is gone in a few hundred years. Also gone is uranium employed in existing and planned reactors. Near term, we could perhaps get primary power and avoid the worst warming by employing coal with CO₂

sequestered, existing nukes, and renewables. But this isn’t sustainable on the millennium timescale where solutions in sight for hundred-terawatt civilization on Earth are terrestrial solar and wind with advanced transmission and storage, space solar power, and fusion. Colleagues and I propose “Apollo” type R&D programs aimed at this goal starting *now*.

3. BIODIVERSITY – A priceless legacy of millions of plant and animal species, including “charismatic megafauna” so emotionally dear to humans – gorillas, chimpanzees, lions, rhinos, giraffes, elephants, tigers, hippos, and the like – is threatened with extinction as *Homo sapiens*, already six billion plus, continues to sprawl the Earth. Some 40% of land surface is appropriated by humans and their domestic animals now. And biofuel energy would likely compete with human agriculture, afforestation, and biodiversity habitat for land, particularly in the tropics where rainforest destruction is already critical. Valuing the integrity of natural ecosystems, an ethical choice, would shift priorities to minimum-footprint energy technologies, like space solar power, for tropical developing nations, where wireless cellphones have already preempted land lines. On a millennial timescale, a philosophical Home Planet stewardship commitment could lead to “re-wilding” the built environment, with corridors for animal passage between large natural parks. In time, the whole Earth might become a kind of natural park preserve, with manufacturing migrating to space colonies, materials mined from asteroids, and energy derived, 24 hours a day, 7 days a week, from the sun, our natural fusion reactor 150 million kilometers distant, as humans approach a Kardashev-Sagan Type I civilization.



Feng Hsu

“Harnessing the Sun: The Next Giant Leap in the Evolution of Humanity”

As humanity enters the new millennium with some of the most profound challenges ever encountered in the history of mankind, I believe that (1) Energy and Sustainability, (2) Human Adaptability and Survival, and (3) Guided Human Creativity and Balance of Global Geopolitical Power Systems are, among others, the three most critical issues confronting humanity today and perhaps for the next few thousand years ahead.

1. Energy and Sustainability

The current global ecological crisis is caused largely by the “petrochemical civilization” of mankind, as the world economy since the industrial revolution has been built upon a non-sustainable

energy resource. Given the energy technology status today and the fact of greenhouse gases from fossil fuel consumption, mankind is consuming too much (energy, food, and water) and their developments have severely diminished natural ecosystems of this planet. The Earth system's biogeochemical cycling of energy and nutrients has been ripped apart and subsequently the global ecological system that provides humans their habitat is failing. Indeed, there is little hope of the Earth and humanity regaining a state of balance unless a major revolutionary shift is underway in ecological based policies in virtually every human realm of activities. Therefore, the ultimate solution lies in the sustainability of energy resources that produce no harm to the Earth environment. The most viable, logical, and ultimate energy resource (among many other renewable energy forms) for mankind for thousands and millions of years ahead is naturally from harnessing the unparalleled power of our solar system – the SUN! The energy sustainability determines virtually every aspect of the challenges for sustained human development. Much like our ancestors had learned the use of “fire,” which leapfrogged human civilization into the stages of cooking and tool-making, harnessing the energy of the Sun will not only reduce or diminish many of our crises, but it most certainly is going to bring about the next giant leap in the evolution of humanity. However, it will be unlikely to achieve this next giant leap of humanity within a foreseeable future, unless a collaborative human endeavor of a “Manhattan Project”-like program on solar energy R&Ds (both land and space-based) is embarked on by the collective wisdom of the entire global society.

2. Human Adaptability and Survival

As it becomes ever more evident, based on a most recent discovery by NASA GSFC, there has been nearly a 10% per decade decrease of ice cover in the Antarctic and a 31% melt increase in the Greenland ice from 1979 to 2005. Regardless of natural or human causes, the global climate is changing at an alarming rate. The Vikings disappeared from Greenland during the medieval age, some 15 thousand years ago, because they did not adapt to a few degrees of temperature change. While determined to reduce or eliminate CO₂ emissions, humans must adapt ourselves to the inevitable change of natural conditions under which we must survive. This, of course, includes expanded human explorations in space, science, and technology frontiers for outer space settlement within this millennium, in order to prepare mankind to adapt and survive in other destinations of the solar system should planetary disasters strike humanity. Human adaptability must replace religious beliefs and the image of God as outside of nature, which has given us

rationale for our own destruction of the natural harmony and often justified our plunder of the Earth's resources. We must not attempt to “conquer” nature as we have failed so miserably to conquer our sins. The risks and uncertainty of everlasting ecologic and natural destruction from the creation of the Three Gorges Dam in China will far outweigh the benefits of electrical power, seeing through the shuttered eyes of only a few generations. This is why we must recognize the importance of ecological balance and the interdependence of all lives on Earth. It is not just an issue of avoiding global ecological collapse, the death of billions; it's an issue of the end of human civilization and the survival of humanity.

3. Guided Human Creativity and the Balance of Power

Science and the technological civilization of humanity have reached a pivotal point of overwhelming creativity and productivity, and this has brought mankind not only rapid economic expansions, globalization, and complex societal interdependencies, it also unleashes the unpredictable (oftentimes uncontrollable) technological forces, which are extremely capable in both sides of the destructive and constructive human ventures. Such risks and the susceptibility of planetary ruins or total extinction of humanity via self-destructive human confrontations continue to grow. Poverty, war, technology, and disparity of resource distribution have led to the serious imbalance of the geopolitical power-sharing around the globe, which in turn fueled the hatred and conflict between human civilizations and between the *haves* and *have-nots*, and consequently gave birth to modern terrorism. The cycling of destructive forces is self-compounding, and is driving the rich richer, the poor poorer, and the powerful more dangerous, emboldened to wage wars or use more violent means to resolve confrontations with fellow mankind. All in all, the inability of mankind to guide its own creativities, therefore to manage or balance the global economic and military power, has been largely responsible for the moral and political crises that exist today. And if such a profoundly critical issue is not resolved in the nearest possible future, there are calculable risks that the abuse of power, abuse of science and technology creations will sooner or later bring about the ruin of our planet, and ultimately our total extinction as the human species.



Thorsten Ludwig

ISSUE 1: *The attitude of responsibility and cooperation will bring the sustainable energy society.*

The most important ingredient for the solution of our present energy dilemma is the change in human attitude. Technological development is not necessary but helpful. Even today there are several solutions that would provide enough energy for humanity. Power from tidal waves, geothermal, solar, or saltwater biomass production in deserts would EACH be sufficient for producing all the energy we need. Why do we not use them now? A complex political and social issue. One very important part is the present attitude by many people, starting from the car driver up to the corporation manager and politicians, to first look for their own benefit and short-term gain. I say that greed and egoism are the main problems. If we shift our attitude towards responsibility and cooperation, we can easily overcome the energy crisis. There are several solutions ready for use. But implementation needs a joint effort by society and nations together. Luckily more and more people of all parts of society realise that something needs to be done and among many responsible environmentalists and parents also some sensible billionaires and politicians start to push for action. The more visible climate changes like the opening of the northwest passage (melting of the ice caps) and wind speed data make more people aware. The price for oil is now high enough for biofuels to become competitive so even the profit-oriented market players start to move.

For this research to become possible and successful, the society needs to allow it. In academia, especially in Europe, it is very difficult to do this research because a large number of professors have prejudices against certain ideas. Most research is oriented on short-term industrial development in popular areas like semiconductor research. There is little room for new ideas. Again: the attitude becomes important. Our mindset determines if we use these new technologies for the betterment of mankind or for war and destruction. It is our choice.

ISSUE 2: *Geothermal, tidal waves, and solar – each provides enough energy for humanity now; some development needed.*

Apart from the mentioned ready solutions there are further potent and interesting energy technologies that need some more research and development to become ready for the market. Geothermal and solar need low-pressure steam generators, which are in development. If we have complete systems for 30 kW to 10 MW solar and geothermal power production, these decentralised solutions could provide cheap

and easy electrical and thermal energy for most people on this planet.

ISSUE 3: *We live in a sea of quantum energy; with research we can learn to use it and to build wonderful new devices.*

The use of quantum mechanical radiation fields could be an enormous energy source for the future. Physics provides us with the knowledge that space is not empty and that we live in a sea of energy. This energy can be used, in theory. It is the present challenge in research to find ways to use these energies. Creative inventors have come up with many solutions. Funds and scientific institutes are necessary to evaluate their claims and to organise research and development of these ideas. With this new energy source we can build smart new vehicles and other applications with integrated energy sources, because of the high energy density of the quantum field. Since the nature of the radiation field seems to be a stochastic one, the results of the Princeton engineering anomalies research group (PEAR) can play a major part in these new technologies. PEAR found out that the people can influence stochastic processes with their attitude. Furthermore, there is very scientific research that hints that low-temperature nuclear reactions are indeed a reality that can lead to new technologies.



John C. Mankins

- The Need for New, Carbon-Neutral Sources of Baseload Electricity and Hydrocarbons
- The Need for Immediate and Sustainable Action to Ameliorate and Reverse Global Climate Change
- The Urgent Need for New Energy Sources to Inherently Stabilize – Rather than De-stabilizing – Global Affairs

1. *Sustainable Sources of Baseload Electricity and Hydrocarbons*

During the coming few decades, supplies of petroleum and natural gas fossil fuels will permanently fall behind supplies. This will lead to an enduring spike in energy prices, with significant consequences to the global economy and to the struggle among nations and regions for energy. In the short term, there will likely be a push to “fix” this crisis through massive coal gasification and other fossil fuel-based alternatives such as shale oil. However, with 100–200 years, even these sources will be depleted; these measures are stopgaps at best. Worse, meeting the vast new demand for energy and hydrocarbons that is expected during the coming century with fossil fuels could have terrible consequences for local environments (e.g., strip min-

ing, water pollution by effluents) and global climate (e.g., warming, storm intensity increases, etc.).

There is a critical need for sustainable and affordable new technologies that can provide both baseload electricity *and* world economy-scale hydrocarbons, without permanently damaging local environments or the global climate.

2. Immediate and Sustainable Action to Ameliorate and Later Reverse Global Climate Change

In just the past two decades, widespread recognition has emerged that human activities are having substantial impact on the global climate – particularly in terms of greenhouse gas emissions and global warming. Even in the U.S., during the past 5 years, there has been a “sea-change” in the discussion. However, there continue to be no signs that the burgeoning Chinese powerhouse has any intention to take actions that might slow the ongoing 10% per year growth in the economy of China. Moreover, although potential solutions involving bio-mass (e.g., ethanol from corn) have begun to be promoted by the U.S. and other governments, there are likely to be serious consequences for fresh water usage and food production if huge amounts of energy are produced from these sources.

In the immediate future, micro-economic solutions, such as increased efficiency in energy use, and macro-engineering solutions, such as carbon sequestration on a vast scale, may be elements of a global plan of action. However, in the longer term it is critical that we develop and deploy on a large scale new energy sources that are inherently carbon-neutral, while still being affordable.

3. New Energy Sources to Inherently Stabilize – Rather than De-stabilizing – Global Affairs

There are real and growing risks of regional and global strife that could result from the rapidly changing energy marketplace and impacts of global climate change. At the same time, the concentration of energy reserves and resulting wealth in the hands of energy-producing countries that are economically or ideologically opposed to the values and interests of energy-consuming countries dramatically exacerbates these risks. Worse, some energy solutions could solve one problem – reducing greenhouse gas emissions – while making others worse, e.g., by leading to the global proliferation of nuclear materials that could be readily “weaponized.”

There is an urgent need for new energy sources that can meet market demand for electricity and hydrocarbons on a sustainable, multi-generational basis – without raising the specter of an “energy Armageddon.” These new energy technologies must inherently stabilize – rather than de-stabilizing – the course of global affairs.



George E. Mueller

1. Population explosion

2. Exhaustion of our carbon deposits

3. Failure to develop and use nuclear energy



Fabrizio Pinto

An imaginary gathering of wise men and women held in the city of Knossos, Crete, during the Middle Minoan Period to contemplate challenges and potential achievements of *their* next thousand years would have been justified to have great expectations. That young palace culture had remarkable technological vitality, a workable form of writing, and a degree of enthusiasm for the beauty of the natural world expressed through art which can still inspire us today. If we allow ourselves a fair degree of poetic anachronism, we can envision a “Humanity -1000” Program, which could have been held in 1993 BCE in a room not too different from the awe-inspiring Throne Room of the Palace of Knossos as it is presently restored (dated to approximately 1450 BCE).

However, despite such great promises for the future millennium, a new meeting held in 993 BCE – a “Humanity 0” Program – would have had little to boast for the recent centuries of that particular culture. Not only had the Mycenaean invasions brought a sudden end to the previous world order, but the sudden explosion of the caldera on Thera had produced a natural catastrophe of epic proportions. Entire cities had been obliterated from the face of the Earth and writing had all but disappeared along with the exquisitely refined palatial culture only to leave the stage to an age of darkness.

Surprisingly, a “Humanity +1000” seminar, most certainly to be held in Alexandria, Egypt, in 7 CE could have provided a radically optimistic view of the next thousand years. Geometry, astronomy, engineering, physics, philosophy, and art were reshaping the lives of Alexandrians in ways quite similar to what occurs in our own present society. Another momentous change in the world order had just occurred with the end of the Ptolemaic dynasty at the hands of the Romans. However, just as in the case of the Mycenaeans, this fierce conqueror had been culturally conquered by those he had vanquished. If a seminar participant had expected mathematical analysis – calculus – to be formally developed within the following millennium, that hope would have been logically justified.

Instead, frustratingly, the last hypothetical meeting held before the one now at hand, in 1007 CE,

most likely in Constantinople, would have had little for which to hope. What was left of the Eastern Roman Empire was engaged in a vicious war against the Bulgars to the West; the South was very unstable and a conflict with the Fatimids was easy to foresee. To the East, the Turkish hoards of Alp Arslan were about to unleash their fury.

With this brief premise, it appears to me that the most critical issue of the next thousand years is for humanity to appreciate that our ancestors have more than once seen centuries of darkness *follow* the light of progress because of natural catastrophe, war, and ideology, often in combination. The first and fundamental challenge to face us in the future, as in the past, is therefore to ensure that a group of social human beings will even exist for whom culture as we intend it today will have a meaning and some relevance.

The second challenge will be a continued transition away from managing the material resources around us as independent from the quantum vacuum within which they exist and towards considering the vacuum as one additional material resource. We will learn to consider the quantum vacuum as another “engineering material” to be used to manufacture structures capable to carry out previously impossible tasks on all scales.

Thirdly, a propulsion revolution will be enabled by exploiting the gravitational field as yet another “material” interacting with ordinary matter and the vacuum. This achievement will allow humans to meet the challenge of interstellar travel and galactic exploration.



Darel Preble

1. *Peaking global oil production*, with occasional price shocks, has begun penetrating the technical, popular, and political spheres, with initial focus being argument on fixing a precise date. As the DOE’s Hirsch report pointed out, “33 out of 48 of the largest oil producing countries have hit peak. It will require more than a decade to transition our civilization away from our heavy dependence on oil. Nothing close to the efforts envisaged have yet begun.”

The grave problem we face in this context is the difference between the “quick fix” mentality – which has produced a welter of well-funded and subsidized “solutions” including ground solar, bioethanol, and wind power. None has grasped an appreciation for the magnitude of the approaching strategic energy shortfall or the complex costs associated with each incorrect method of addressing the energy threat.

2. One growing impact of our choice to subsidize bioethanol is the *conflict between food production and fuel production*. As a result, corn prices have been soaring and are expected to go higher. The typical Mexican family consumes one kilo of tortillas per day. The price per kilo has risen from 63 cents a year ago to between \$1.36 and \$1.81 earlier this month. With a minimum wage of \$4.60 a day, Mexican families with one wage earner have been faced in recent months with the choice of spending a third of their income on tortillas, eating less, or switching to cheaper and far less nutritious alternatives, such as instant noodles, at 27 cents a cup. Mexico is representative, but far from unique. We simply cannot produce enough liquid fuels represented by declining global oil production, with fuels from our fields. Demand is too great. We are aware of just one clean baseload alternative equal to the immense task – SSP [space solar power].

3. Other *major issues such as climate change constrain our choice of how to replace this massive quantity of energy*. The following chart of many other energy choices is a brief summary of why SSP, in the final analysis, is the only way forward. A more detailed analysis is available through the SSPW [Space Solar Power Workshop].

	Clean	Safe	Reliable	Baseload
Fossil Fuel	No	Yes	How Long?	Yes
Nuclear	No	Yes	Fuel??	Yes
Wind	Yes	Yes	No	No
Ground Solar	Yes	Yes	No	No
Hydro	Yes	Yes	No; scheduled	
SSP	Yes	Yes	Yes	Yes



Crispin Tickell

Paradoxically it may be easier to look forward a thousand years rather than the next twenty. On the hopeful assumption that our species still exists, our descendants, in whatever genetic form, will have had to survive combinations of natural as well as human-made disasters, and come to different and more friendly terms with the natural environment. There is never going to be a shortage of energy to drive what is likely to be a much smaller, more dispersed, and electronically linked society. Instead of using up ancient reserves of stored sunlight, they will be using energy derived from a variety of sources, including some directly from the Sun, others from heat from within the Earth, others from the movement of tides, and others from crops cultivated for the purpose. In their own interest, they will practice an ethical system in which the natural world has value not only for human welfare but also for and in itself.



Thomas F. Valone

Today the issues of energy, population, and pollution are the three major issues facing mankind.

1. ENERGY – The world community has depended upon a dead, morbid source of energy, namely “fossil fuels,” which, from their archetypal essence, can only engender more death, pollution, and decay as they are used. Furthermore, textbooks on the subject cite the fact that societies historically need more complex forms of energy in order to keep growing economically. There is very little hope that the energy density of the fossil fuels we use, such as gasoline, diesel, or jet fuel, for example, will ever become higher. Therefore, it is logically imperative that a new, completely different form of energy be discovered and utilized that is the opposite of what we use today. It is also a great desire of the energy scholars that, ideally, future energy will have life-giving properties, such as

renewability and inexhaustibility, with the potential of concentrated versions if needed. Presently, many solar and wind energy systems are a wonderful solution but the high-efficiency flexible silicon panels that also convert ambient temperature heat will emerge as a more versatile solution. The only form of energy that satisfies all of the above characteristics of an ideal future energy is zero point energy, the subject of my latest book.

2. POPULATION – Today, the Earth is overpopulated with unprecedented high-density population cities. Without the discovery of nitrate production for artificial fertilizers in the middle of the last century, food production could never have sustained a doubling of the number of people on the Earth, as we have seen in our lifetime. There are many impending disasters awaiting a large population, which only happen every few centuries. Those that target large cities on the coastline of a country include (a) tsunamis from offshore earthquakes (e.g., Seattle, WA), half-island landslides (e.g., Canary Islands), and small near-Earth objects hitting any one of the oceans, and (b) rising ocean levels due to global warming and the melting of the arctic ice. Those that target large numbers of people, due to population density average throughout a country, include volcanic eruptions (e.g., caldera at Yellowstone National Park), and increasing strength of tornadoes, typhoons, and hurricanes with global warming.

3. POLLUTION – This subject is unfortunately only of concern to some of the developed countries. Furthermore, the definition of environmental pollution should include various poisonous nitrogen, sulfur, and carbon oxides in gaseous form, as well as the dissolved acids that are produced in the water systems and concentrated in the fatty tissue of animals and people. Unfortunately, air and water flow throughout the world and across international boundaries, so cooperation is needed to solve the problem. Solving #1 and #2 above will necessarily ameliorate the pollution they generate. It will be a great step forward for the EPA to start regulating carbon dioxide pollution, for example, which is a major contributor to global warming.

Appendix C: Participant Biographies



Howard Bloom

Howard Bloom is a recent visiting scholar in New York University's Graduate Psychology Department and a former faculty member of The Graduate Institute. He is the founder of the International Paleopsychology Project, a founding board member of the Epic of Evolution Society, a founding council member of The Darwin Project, a member of the Board of Governors of the National Space Society, and the author of two critically acclaimed books, *The Lucifer Principle: A Scientific Expedition into the Forces of History* and *Global Brain: The Evolution of Mass Mind from the Big Bang to the 21st Century*. He has also lectured at Wesleyan, NYU, and the University of Georgia.

Bloom has labored to create two new fields: paleopsychology and mass behavior. His next goal is to establish a discipline he calls "omnology." Bloom's cross-disciplinary theories trace crowd patterns from the precipitation of the first protons in the Big Bang to future trends in the life of humankind. For Bloom, mass behavior, paleopsychology, and omnology are fields that encompass nearly everything man can know – physics, mathematics, nucleocosmochronology, biology, psychology, geopolitics, the arts, the evolution of galaxies, bacteria, crustaceans, lizards, and *Homo sapiens* – and the emergence of human tribes, world history, religion, mysticism, rationality, war, hatred, delight, science, and technology. Britain's Channel 4 TV has said, "Howard Bloom is next in a lineage of seminal thinkers that includes Newton, Darwin, Einstein, Freud, and Buckminster Fuller ... he is going to change the way we see ourselves and everything around us."

Bloom got his start in science early. He grew up in Buffalo, NY, and dove into cosmology, theoretical physics, and microbiology at the age of ten, built his first Boolean algebra machine when he was twelve, crafted the concept for a prize-winning computer at the age of thirteen, participated in research on the immune system at the world's largest cancer research center (The Roswell Park Memorial Cancer Research Institute in Buffalo, NY) at sixteen, and did research on programmed learning at Rutgers University's Graduate School of Education before his freshman year of college. From 1968 to 1988, Bloom created a new form of participatory research in cultural evolution, political science, and social psychology. He turned down four graduate

fellowships in clinical psychology and embarked on what he calls his "Voyage of the Beagle," an expedition to "the heart of the beast, to the dark underbelly where new myths and new shifts in mass emotion are made." Those 20 years of fieldwork allowed Bloom to test his theories of mass emotion in the laboratory of reality. In 1976 Bloom founded one of the leading entertainment public relations firms of the 1970s and 1980s, the Howard Bloom Organization, Ltd., which worked with films ranging from *Purple Rain* and the Talking Heads' *Stop Making Sense* to *Down and Out in Beverly Hills*, *Ruthless People*, and *Outrageous Fortune*. He helped build the careers of Prince, Bob Marley, Bette Midler, Michael Jackson, Billy Joel, Paul Simon, Billy Idol, Peter Gabriel, David Byrne, John Mellencamp, AC/DC, Aerosmith, and Queen. Bloom also wrote position papers for two winning political candidates and founded and ran the leading national music anticensorship group of the mid-1980s (Music in Action). From each of these experiences Bloom gained new insights that have given depth to his scientific theories. His *chef d'oeuvre* is a project he's spent 50 years assembling, the 4,300 chapters of what he calls "The Grand Unified Theory of Everything in the Universe Including the Human Soul."

RECENT, RELEVANT PUBLICATIONS

"Folgt dem Führer." *Kunstforum International*. November 1999.

"Metaphor of the Automobile Clutch for Thalamus & Striatum." *ASCAP – Across-Species Comparisons and Psychopathology*, Vol. 12, No. 12. December 1999: 14.

"Outside the Body." *ASCAP – Across-Species Comparisons and Psychopathology*, Vol. 13, No. 1. January 2000: 23–24.

Global Brain: The Evolution of Mass Mind from the Big Bang to the 21st Century. New York: John Wiley & Sons, 2000.

"Instant Evolution: The Influence of the City on Human Genes: A Speculative Case." *New Ideas in Psychology*, December 2001.

"The Xerox Effect: On the Importance of Pre-Biotic Evolution" in *PhysicaPlus*, the online publication of The Israeli Physical Society. January 10, 2004.

With Pavel V. Kurakin and George G. Malinetsky. "Conversation (dialog) model of quantum transitions." In *arXiv.org*, an online physics and math resource founded by the Los Alamos National Lab. April 2005.



Dennis M. Bushnell

Dennis M. Bushnell is Chief Scientist at NASA’s Langley Research Center. He is responsible for technical oversight and advanced program formulation with technical emphasis in the areas of atmospheric sciences and structures, materials, acoustics, flight electronics/control/software, instruments, aerodynamics, aerothermodynamics, hypersonic airbreathing propulsion, computational sciences and systems optimization for aeronautics, spacecraft, exploration, and space access. Bushnell has 43 years’ experience as Research Scientist, Section Head, Branch Head, Associate Division Chief, and Chief Scientist. His technical specialties include flow modeling and control across the speed range, advanced configuration aeronautics, aeronautical facilities, and hypersonic airbreathing propulsion. He has authored 247 publications/major presentations and 310 invited lectures/seminars.

Bushnell is a member of the National Academy of Engineering and a Fellow of ASME, AIAA, and The Royal Aeronautical Society. He holds six patents. Other honors include the AIAA Sperry Award, Fluid and Plasma Dynamics Award, AIAA Dryden Lectureship, as well as the Royal Aeronautical Society Lanchester, Swire and Wilber and Orville Wright Lectures, ICAS Guggenheim Lecture, Israel Von Karman Lecture, USAF/NASP Gene Zara Award, NASA Exceptional Scientific Achievement and Outstanding Leadership Medals, Distinguished Research Scientist Award, ST Presidential Rank Award, nine NASA Special Achievement and ten Group Achievement awards, University of Connecticut Outstanding Engineering Alumni Award, Academy of Engineers Award, Pi Tau Sigma and Hamilton awards, and University of Virginia Engineering Achievement Award. He has also served on numerous national and international technical panels and committees, and been a consultant to national and international organizations. DOD-related committee/consulting assignments include USAF Rocket Propulsion Laboratory, BMDC, ONR, Intelligence Community/STIC, AFOSR, NRAC, NRC, WL, LLL, HASC, NUWC, DARPA, AGARD, ARL, IAT, AEDC, JANNAF, NAVSEA, Air Force 2025, AF-

SOC, Sandia, SAB, Army War College, ACOM Joint Futures, SOCOM, TRADOC, SEALS, JFCOM, IDA, NDU, DSB, and Army After Next. He has been a reviewer for 40 journals and organizations, and Editor of Volume 123 of the AIAA Progress Series “Viscous Drag Reduction in Boundary Layers.”

Bushnell is responsible for the invention/development of the “Riblet” approach to turbulent drag reduction, high-speed “quiet tunnels” for flight-applicable boundary layer transition research, advanced computational approaches for laminar flow control, and advanced hypervelocity airbreathing and aeronautical concepts with revolutionary performance potential. He has contributed to national programs including Sprint, HSCT/SST, FASTSHIP, Gemini, Apollo, RAM, Viking, X15, F-18E/F [patent holder for the “fix” to the wing drop problem], Shuttle, NASP, submarine/torpedo technology, America’s Cup racers, MAGLEV trains, and planetary exploration. He earned a B.S. degree in mechanical engineering, with Highest Honors Distinction, from University of Connecticut, and a master’s degree in mechanical engineering from University of Virginia.

RECENT, RELEVANT PUBLICATIONS

“Précis of Post-Petroleum Energetics including Seawater Agriculture.” Conference on Future Energy [COFE] 2. Sept. 22–24, 2006, Silver Springs, MD.

“Seawater/Saline Agriculture for Energy, Water, Land, Food and Warming.” In Mohamed Gad-el-Hak (Ed.) *Large Scale Disasters: Prediction, Control and Mitigation*, to be published by Cambridge University Press, 2007.

“Green[er]-to-Green Aircraft/Aeronautical Possibilities.” Royal Aeronautical Society Meeting “Air Travel – Greener by Design.” London, UK, 5 October 2006.

“A Review of US Air Force and Department of Defense Aerospace Propulsion Needs.” National Academy Press, 2006.

“Energy Futures.” In “2020 Future Technology Landscape.” National Intelligence Council. [In Review].

“Energy Harvesting Net Assessment” for DDR&E, 2006.



William H. Calvin

William Calvin, Ph.D., is a Professor Emeritus at the University of Washington School of Medicine in Seattle.

He is also affiliated with Emory University's great apes project and on the Board of Advisors of the Foundation For the Future.

Calvin has written 14 books for general readers. His 2008 book is *Global Fever: How to Treat Climate Change*: While covering the "What's Up" aspects of other global-warming books, he also examines why a double-duration El Niño is so threatening; addresses our closing window of opportunity to halt the warming and then restore our climate to what the Earth had before the fossil-fuel surge after 1950; and then spends five chapters on "What to do about it."

His 1998 cover story for *The Atlantic Monthly*, "The Great Climate Flip-flop," was the first major magazine article on the now-familiar subject; it grew out of a long-standing interest in abrupt climate change and how it influenced the evolution of a chimpanzee-like brain into a more human one. He expanded on these topics in *A Brain for All Seasons: Human Evolution and Abrupt Climate Change*, which won the 2002 Phi Beta Kappa Book Award for Science and the 2006 Walter P. Kistler Book Award.

A Brief History of the Mind: From Apes to Intellect and Beyond (2004) addresses what led up to the "Mind's Big Bang" about 50,000 years ago, a creative explosion compared to the very conservative trends in toolmaking over the previous 2.5 million years. That span featured two million-year-long periods without much progress – despite the growth in brain size.

Calvin's neurobiology research interests primarily concern the neocortical circuits used for detailed planning and for improving the quality of the plan as you "get set," presumably utilizing a milliseconds-to-minutes version of the same Darwinian process (copying competitions biased by natural selection) seen in the immune response and species evolution on longer time scales. His research monograph, *The Cerebral Code: Thinking a Thought in the Mosaics of the Mind* (1996), concerns Darwinian processes in neural circuitry that can operate on the timescale of

thought and action to resolve ambiguity and shape up novel courses of action. He also collaborated with the linguist Derek Bickerton to write *Lingua ex Machina: Reconciling Darwin and Chomsky with the Human Brain* (2000) about the evolution of syntax.

Following studies in physics at Northwestern University, Calvin branched out into neurophysiology via studies at MIT, Harvard Medical School, and the University of Washington (Ph.D., physiology and biophysics, 1966). For twenty years, he talked shop every day with the neurosurgeons, then moved on to the biologists, psychologists, anthropologists, and psychiatrists. Presently he is concentrating on climate scientists.

RECENT, RELEVANT PUBLICATIONS

Global Fever: How to Treat Climate Change. University of Chicago Press, 2008. Excerpts at Global-Fever.org.

Almost Us: Portraits of the Apes. Private printing, 2005. Excerpts at apes.WilliamCalvin.com.

A Brief History of the Mind: From Apes to Intellect and Beyond. Oxford University Press, 2004.

A Brain for All Seasons: Human Evolution and Abrupt Climate Change. University of Chicago Press, 2002.

"Abrupt Climate Jumps and the Evolution of Higher Intellectual Functions during the Ice Ages." In R.J. Sternberg (Ed.) *The Evolution of Intelligence* (Erlbaum), 2001, pp. 97–115. See also WilliamCalvin.com/1990s/1999intelligence-chapter.htm.

Co-authored with Derek Bickerton. *Lingua ex Machina: Reconciling Darwin and Chomsky with the Human Brain*. MIT Press, 2000.

"The Great Climate Flip-flop." *The Atlantic Monthly*, 281(1) (1998), 47–64, at WilliamCalvin.com/1990s/1998AtlanticClimate.htm.

The Cerebral Code: Thinking a Thought in the Mosaics of the Mind. MIT Press, 1996.

How Brains Think: Evolving Intelligence, Then and Now. Perseus Publishing, 1996.

Co-authored with George A. Ojemann. *Conversations with Neil's Brain: The Neural Nature of Thought and Language*. Perseus Publishing, 1994.



Eric J. Chaisson

Dr. Eric J. Chaisson is Director of the H. Dudley Wright Center for Innovative Science Education at Tufts University, where he is also Research Professor of physics and astronomy and Research Professor of education. He is also an Associate of the Harvard College Observatory, where he teaches introductory astrophysics, and Affiliate-director of the Massachusetts Space Grant Consortium, based at MIT.

Trained initially in atomic physics, Chaisson obtained his doctorate in astrophysics from Harvard University in 1972. Before assuming his current position, he spent a decade as a member of Harvard's Faculty of Arts and Sciences. During his tenure as Associate Professor at the Harvard-Smithsonian Center for Astrophysics, Chaisson's research concentrated largely on the radio astronomical study of interstellar gas clouds. This work won him fellowships from the National Academy of Sciences and the Sloan Foundation, as well as Harvard's Bok Prize for original contributions to astrophysics and Harvard's Smith-Weld Prize for literary merit. He has also held research and teaching positions at MIT and Wellesley College and, before joining Tufts, was a scientist on the senior staff and Director of educational programs at the Space Telescope Science Institute at Johns Hopkins University. He has more than 100 publications to his credit, most of them in the professional journals.

Chaisson's major research interests are currently twofold: His scientific research focuses on an interdisciplinary, thermodynamic study of physical and biological phenomena, thereby searching for the origin, evolution, and unification of galaxies, stars, planets, and life forms in the universe. His educational research engages experienced teachers and computer animators to discover better methods, technological aids, and novel curricula to enthuse teachers and instruct students in all aspects of natural science. He currently teaches an undergraduate course at Harvard University on the subject of cosmic evolution, which combines both of these research and educational goals.

In order to share the essence of his research and

teaching with a wide audience, Chaisson has written several books, including *Cosmic Dawn*, which won several literary awards such as the Phi Beta Kappa Prize, the American Institute of Physics Award, and a National Book Award Nomination for distinguished science writing. His other books include two works on relativity, a textbook on cosmic evolution, and a volume (co-authored with George Field) outlining the scientific rationale for the United States' national space policy. Another book, *The Hubble Wars*, also won the American Institute of Physics Science Writing Award, and his popular textbook, *Astronomy Today* (co-authored with Steve McMillan), is the most widely used college astronomy textbook in the nation. His most current books, *Cosmic Evolution: The Rise of Complexity in Nature*, and *Epic of Evolution: Seven Ages of the Cosmos*, were published by Harvard and Columbia University Presses, respectively. The latter won the Walter P. Kistler Book Award for 2007.

Chaisson holds membership in numerous American and international scientific organizations, several honor societies, and a host of academic, public, and federal advisory committees.

RECENT, RELEVANT PUBLICATIONS

“A Unifying Concept for Astrobiology.” *International Journal of Astrobiology*, Vol. 2, p. 91, 2003.

“Complexity: An Energetics Agenda.” *Complexity, Journal of Santa Fe Institute*, Vol. 9, p. 14, 2004.

“Non-equilibrium Thermodynamics in an Energy-rich Universe.” In A. Kleidon and R. Lorenz (Eds.) *Non-Equilibrium Thermodynamics and Production of Entropy*, Springer-Verlag, 2005.

“The Great Unifier.” *New Scientist*, Vol. 189, p. 36, 2006.

“Rhythm of the Cosmos: Finding Unity among the Natural Sciences.” *Tufts Magazine*, p. 16, Spring 2001.

Cosmic Evolution: The Rise of Complexity in Nature, Harvard University Press, 2001. ISBN 0-674-00342-X.

Epic of Evolution: Seven Ages of the Cosmos, Columbia University Press, 2006. ISBN 0-231-13560-2.

With S. McMillan. *Astronomy Today*. Pearson Education, 6 editions: 1993–2008. ISBN 0-13-091542-4.



Russ George

Russ George has worked in science, especially environmental and energy science, for the past 30 years specializing in technology transfer of academic discoveries into practical applications.

He has worked as both a professional manager and businessman in both the United States and Canada, and managed projects including large-scale reforestation and land reclamation in the forestry and mining industry, development of ocean fisheries enhancement and aquaculture projects, and environmental management of major development projects including multi-billion-dollar resource-development projects in Northern Canada. He is also an acknowledged leader in several cutting-edge fields of catalytic energy science. In the mid-1970s, George served as a professional Scientific Field Advisor and “Officer of the Queen” in Canada’s Ministry of Energy, Mines, and Petroleum Resources. In the intervening years, he has developed broad expertise in many energy-related disciplines including nuclear physics, chemistry, acoustics, and materials science. His independent research career in energy physics has included numerous stints running experiments as a Visiting Scientist at Los Alamos National Laboratory, Lawrence Berkeley National Laboratory, Pacific Northwest National Laboratory, Stanford Research International, the University of Osaka, and Portland State University. He has also collaborated in the design and execution of catalytic energy experiments with the US Naval Research Laboratory and the Electric Power Research Institute (EPRI). He is an associate with International Offsets Unlimited Inc., a company

retained by large energy companies to develop greenhouse gas mitigation technologies, and he serves as a Director with the IgA Nephropathy Foundation.

Russ George is often interviewed by the media on the future of energy and environment, and has given invited speeches to such organizations as the US Department of Defense (SecNav), NASA, Department of Energy, Electric Power Research Institute, Canadian Institute of Energy, Lockheed Martin, and General Atomics, as well as similar organizations in Japan and Europe. He is an award-winning producer, writer, and director of films and television, especially focusing on environmental topics in both the United States and Canada. He is an avid ocean sailor, explorer, naturalist, and long ago stood night watch for a time at the wheel of the late *Rainbow Warrior*. Russ George is recognized by his peers in the scientific community as a creative source of innovative concepts and meta-analytic synthesis of information from diverse disciplines.

RECENT, RELEVANT PUBLICATIONS

“Experimental Evidence of Radiationless Aneutronic Nuclear Fusion in Metal Deuterides.” American Physical Society, Annual March Meeting, March 16–20, 1998. Los Angeles, CA. Abstract #U26.02.

“Experiment and Theory for Nuclear Reactions in Nano-Materials Show e14 – e16 Solid-State Fusion Reactions.” American Physical Society, APS March Meeting, March 21–25, 2005. Abstract #U33.008.

“Morphology of Fission Gas Bubbles in Fissioning Uranium Metal Closely.” American Physical Society, APS March Meeting, March 21–25, 2005. Abstract #U33.014.



Jerome C. Glenn

Dr. Jerome C. Glenn co-founded and directs the Millennium Project, the leading global participatory think tank supported by international organizations, governments, corporations, and NGOs, which has produced the internationally recognized *State of the Future* annual reports for the past ten years. The 2006 report includes a major study that produced four Global Energy Scenarios. He has also been, since 1988, the Executive Director of the American Council for the United Nations University, which represents the UNU in Washington, DC.

Glenn has 37 years' experience in futures research for government, international organizations, and private industry in science and technology policy, economics, education, defense, space, forecasting methodology, international telecommunications, and decision support systems with the Millennium Project, Committee for the Future, Hudson Institute, his own firm (the Future Options Room), and as an independent consultant.

He is the author of over 100 future-oriented articles in such publications as *The New York Times*, *Nikkei*, *ADWEEK*, *International Tribune*, *LEADERS*, *Foresight*, *Technological Forecasting*, *Futures Research Quarterly*, and *The Futurist*. He was co-author of 1997 (through) 2007 *State of the Future*; Editor of *Futures Research Methodology* (1999 and 2003); author of *Future Mind: Merging the Mystical and the Technological in the 21st Century* (1989 and 1993) and *Linking the Future: Findhorn, Auroville, Arcosanti* (1979); and co-author of *Space Trek: The Endless Migration* (1978 and 1979).

Glenn was the Deputy Director, PFP International, involved in micro-credit, national strategic planning, institutional design, training, and evaluation in economic development in Africa, Middle East, Asia, the Caribbean, and Latin America. He also founded CARINET, the computer network, in 1983 (now owned by CGNET), and has consulted for corporations, USAID and its contractors, World Bank, UNDP, UNU, UNEP, UNESCO, US Army, DOE, and several governments.

He has keynoted conferences for over 100 corporations, associations, governments, universities, and international organizations; invented the “Futures Wheel” forecasting technique and Futuristic Curriculum Development; was instrumental in SALT II section that banned the first space weapon (Soviet FOBS); was named by *Saturday Review* as among the most unusually gifted leaders of America for his pioneering work in tropical medicine, future-oriented education, and participatory decision-making systems in 1974; was instrumental in naming the first Space Shuttle “Enterprise”; and is a leading boomerang stunt man.

RECENT, RELEVANT PUBLICATIONS

“Thinking Ahead.” *RSA Journal*. Royal Society of Arts, UK, 2007.

International Issues of Environmental Security (monthly scanning reports for the US Army's Environmental Policy Institute. <http://www.aepi.army.mil/rpt-weei.html>).

With Ted Gordon. 2007 *State of the Future*. American Council for the UN University.

“Some Future Threats to Democracy.” *Future of Democracy*, Government of Finland (Finland's Parliamentary Committee for the Future anniversary book).

Global Scenarios and Implications for Constructing Future Livestock Scenarios. Food and Agricultural Organization, Rome, 2006.

Philanthropy in the Early 21st Century: Strategic Considerations. Council on Foundations, 2006.

15 *Global Challenges and Strategies: Creating Global Strategies for Humanity's Future*. World Future Society, 2006.

The State of the Future: Better or Worse. Current, 2006.

“Globalization and Risk Management of Science and Technology.” *International Journal of Technology Management*, 2006.

With David J. LePoire, Argonne National Lab. “Technology and the Hydra of Terrorism?” *Technological Forecasting & Social Change*, 2006.



Gustav R. Grob

Gustav R. Grob founded the International Sustainable Energy Organization (ISEO) for the United Nations in 2002. He also founded in 1991 the International Clean Energy Consortium (ICEC), Zurich/Zug, and was President of this consortium. He was founder of ICEC-ECOLUX Light Technologies, Board Member of the International Energy Foundation IEF, Vice President of HYMOBIL AG (clean mobility), and Council Member of the World Sustainable Energy Coalition (WSEC). Since 2001 he has been Advisory Board Chairman of BLUE PLANET Inc. for investments in sustainable energies. In 1983, he was Co-Founder/President of the “World Circle of the Consensus” CMDC, initiating the World Sustainable Energy Coalition (WSEC) in 1991.

Grob was the 2007 Co-chairman of the RENEWEX exhibition and conference in Dubai and the IIASA Energy Workshop, Stanford University. In 2004–05 he lectured and moderated at the International Energy Conference for Transition Countries in Leipzig; at the European Renewable Energy Conference (EREC) in Berlin; at the REasia in Beijing (also in 2006); at the International Sustainable Energy & Environment Conference in Changsa, China; at the International Conference on Condensed Matter & Nuclear Science (ISCMNS) in Marseille; and at the historic RENEWABLES 2004 Summit in Bonn with over 3000 delegates from 154 nations.

Grob has chaired international conferences on Petroleum & LNG Measurement, Analysis & Loss Control in London, Middlesbrough, Singapore, Bangkok, Melbourne, Newcastle/NSW, Jakarta, Taiwan, Abidjan, The Hague, Mexico City, Orlando, Houston, Vancouver (Canada), Paris, and Geneva. He co-chaired and lectured on the impact of standardization on the process industry in Kuala Lumpur, Malaysia, at IMEKO conferences in Houston, TX, and Beijing on industrial measurement, and on SHEE-TREE (Solar Hydrogen & Electric Energy – Trans European Enterprise) in Zurich, at the UN in New York, and at WHEC in Miami, FL. He was Co-chairman of ENERGEX '96 in Beijing and ENERGEX '98 in Bahrain, ENERGEX '02 in Krakow, and ENERGEX '06 in Stavanger. He chaired the Blue Planet Symposium on Sustainable Energy at Lucerne, Switzerland, in 2001.

He has lectured and given keynote speeches at energy conferences all over the world. The Asian-Pacific Clean Energy Development Plan was started in 1990 by Grob, inspiring also the Japanese WE-NET21. In 1991, he took part in the Energy Planning Conference

at the Asian-Pacific Development Center in Kuala Lumpur, the Global Energy Efficiency Mechanism in Geneva, the Electricity & Environment Conference in Helsinki, the UNCED PrepComs for the historic Rio Summit, the initiation of the World Sustainable Energy Coalition (WSEC), and the World Clean Energy Conferences in Geneva. He was active in “ENERGY 2000” and Swiss Energy Research Conferences. He presented keynote speeches at the Renewable Energy Congress, Reading, UK, in 1992; ENERGEX '94, at Seoul.

Grob was Chief Editor of the historic CLEAN ENERGY 2000 Congress in Geneva, and Chief Editor for the UN World Summit on Sustainable Development (WSSD), Johannesburg, for “Blueprint for the Clean, Sustainable Energy Age.” At the latter summit he was delegation leader for CMDC-WSEC, ISEO, and ISO energy affairs.

Gustav R. Grob, born in Lucerne, Switzerland, is a Swiss graduate Electromechanical Engineer and ETH-BWI (Swiss Federal Institute of Technology, Zurich) Industrial Engineer with IMA-MCE post degrees in physical distribution management and CCG marketing management. He earned a military degree in RADAR engineering at Swiss Air Force. He is a Fellow of the Energy Institute, London (former F.I.P.–Institute of Petroleum). He has published many papers on clean energy, metrology, ecology, sustainable development, logistics management, and business ethics.

RECENT, RELEVANT PUBLICATIONS

“The Code.” CMDC, London, 1986.

“Order in Chaos.” CMDC, Geneva, 1987.

“SHEE-TREE, Solar Hydrogen & Electric Energy – Trans-European Enterprise.” BWE, Bern, 1988.

“Cleaner Energy for Sustainable Development.” World Clean Energy Conference, Geneva, 1991.

Blueprint for the Clean, Sustainable Energy Age. CLEAN ENERGY 2000, Verlag Eco-Performance, Zurich, ISBN 3-9090087-08-6.

Naturally Fit and Healthy, Pocket Book, Eco-Performance Publishers, Zurich, 2004

“Energy and the Human Livelihood Evolution.” Geneva, 2005.

“Overcoming the Fire Age.” PPT, Geneva, 2005, www.uniseo.org.

“Evolution of Wind Power.” PPT, Geneva, 2006, www.uniseo.org.

“Global Transition to Sustainable Energy Security and Safety.” UN-ECE, Geneva, ISEO Newsletter, Autumn, 2006.



Martin I. Hoffert

Dr. Martin I. Hoffert is Professor Emeritus of physics and former Chair of the Department of Applied Science at New York University. His academic background includes a B.S. (1960) in aeronautical engineering from the University of Michigan, Ann Arbor; M.S. (1964) and Ph.D. (1967) from the Polytechnic Institute of Brooklyn (now the Polytechnic Institute of New York) in astronautics; and a Master of Arts in liberal studies (1969) from the New School for Social Research where he did graduate work in sociology and economics. He has been on the research staff of the Curtiss-Wright Corporation, General Applied Science Laboratories, Advanced Technology Laboratories, Riverside Research Institute, and National Academy of Sciences, and was Senior Resident Research Associate at the NASA/Goddard Institute for Space Studies. Prof. Hoffert has published broadly in fluid mechanics, plasma physics, atmospheric science, oceanography, planetary atmospheres, environmental science, solar and wind energy conversion, and space solar power.

His work in geophysics is aimed at development of theoretical models of atmospheres and oceans to address environmental issues, including the ocean/climate model first employed by the UN Intergovernmental Panel on Climate Change (IPCC) to assess global warming from different scenarios of fossil fuel use. His early model of the evolving CO₂ greenhouse in Mars’s atmosphere is also of interest today – providing both an explanation of Mars’s riverbed-like channels formed in the distant past and a motivation for terraforming its atmosphere for human habitability in the future. His research in alternate energy conversion includes wind tunnel and full-scale experiments on innovative wind turbines, photovoltaic generation of hydrogen, and wireless power transmission (WPT) applied to solar power satellites.

Hoffert’s present efforts focus on energy technologies that could stabilize climate change from the fossil fuel greenhouse – including (but not limited to) space solar power. He is a member of the American

Geophysical Union (AGU) and the American Institute of Aeronautics and Astronautics (AIAA), and was elected Fellow of the American Association for the Advancement of Science (AAAS). He is presently a consultant to Lawrence Livermore National Laboratory and Versatility Software, Inc.

RECENT, RELEVANT PUBLICATIONS

“The Cold Equations of Global Warming.” Submitted to *Science*. January 2007.

“An Energy Revolution for the Greenhouse Century.” *Social Research*, 73 (3), 2006, pp. 981–1000.

With K. Caldeira. “Climate Change and Energy, Overview.” In C.J. Cleveland (Ed.) *Encyclopedia of Energy* (Elsevier Science), 2004, pp. 359–380.

With E. Hoffert and P. Soukup. “Power Beaming for Space-based Electricity on Earth: Near Term Experiments with Radars, Lasers and Satellites.” Presented at 4th International Conference on Solar Power from Space – SPS ’04, Granada, Spain, 30 June–2 July 2004. ESA Publications Division, The Netherlands, pp. 195–201.

With K. Caldeira and G. Benford. “Fourteen Grand Challenges: What Engineers Can Do to Prove We Can Survive the 21st Century.” *Mechanical Engineering Power 2003*, pp. 10–16.

With K. Caldeira and A.K. Jain. “Climate Sensitivity Uncertainty and the Need for Energy Without CO₂ Emission.” *Science*, 299. 28 March 2003, pp. 2052–2054.

With K. Caldeira et al. “Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet.” *Science*, 298, 2002, pp. 981–987.

With K. Caldeira and A. Jain. “Simple Ocean Carbon Cycle Models.” In T.M. Wigley and D.S. Schimel (Eds.) *The Carbon Cycle*. Cambridge University Press, Cambridge, UK, 2001, pp. 199–211.

With K. Caldeira et al. “Energy Implications of Future Stabilization of Atmospheric CO₂ Content.” *Nature*, 395, 1998, pp. 881–884.

With C. Covey. “The Sun-Climate Connection: A Challenge to Conventional Wisdom?” *Climatic Change*, 37, 1997, pp. 387–390.



Feng Hsu

Dr. Feng Hsu is a renowned world expert with over 25 years of experiences in the field of risk and safety assessment and mission assurance management for complex engineering systems, such as nuclear power plant systems, space launch vehicle systems, solid rocket booster and interplanetary exploration spacecrafts as well as air or ground traffic control systems for civil aviation. Formerly an Engineering Researcher at Brookhaven National Laboratory (BNL), Dept. of Advanced Technology, he has worked extensively on reliability, Probabilistic Risk Assessment (PRA), and management theory and methodology research for nuclear reactor systems and space launch vehicle systems since the 1980s. He became Sr. Staff Engineer/Scientist and joined NASA's SAIC team in the Space Shuttle and Exploration Analysis Department at Johnson Space Center in Houston, TX, in 2000.

Dr. Hsu has been a lead engineering analyst and project manager working as technical expert in the Space Center on NASA's key program areas, such as Probabilistic Risk Assessment (PRA), Safety and Mission Assurance (SMA) for the Space Shuttle Program (SSP), International Space Station (ISS), as well as the risk-based mission system design assessment for the new generation space launch and crew exploration vehicle (CEV/CLV) systems. He was a key member of the Columbia investigation team at JSC, and he is now a leading engineer on frontier space missions at NASA GSFC. Dr. Hsu has authored over 85 publications, including journal articles, NUREG/CRs, BNL and NASA technical reports as documented for US Nuclear Regulatory Commission, US Department of Energy, US Federal Aviation Administration, and NASA.

Besides being invited referee for several international journals, Dr. Hsu is a member of the Technical Committee of IEEE SMC and Co-chair of the Technical Committee on System Safety and Security. He has regularly chaired technical sessions in various international academic and professional conferences. He earned his undergraduate degree in Applied Math at Chungking University in Sichuan and left China nearly 25 years ago for graduate studies at MSU in the USA. He earned an M.S. in operations research and statistics and a Ph.D. in engineering science.

Dr. Hsu is co-author of the book *Beyond Earth – The Future of Humans in Space*, published in 2006 by Apogee Books, and principal author of major reports of the NASA PRA study for the Space Shuttle STS systems. He has won numerous research and service awards from BNL, SAIC, and NASA. He also received the Brookhaven National Laboratory service award, August 1999, for outstanding work performance, and

US DOE honor for NIAS technique and software development, US National Energy Software Center, Argon National Laboratory, Chicago, January 1994. He is a member of ANS (American Nuclear Society), AIAA (American Institute of Aeronautics and Astronautics), IEEE, ISSAT (International Society of Science & Applied Technologies), and SRA (International Society for Risk Analysis).

RECENT, RELEVANT PUBLICATIONS

With R. Duffey. *Managing Risks on the Space Frontier – The Paradox of Safety, Reliability and Risk Taking*. Apogee Space Book Series, CGPublishing, Chicago, Toronto, NY, 2006.

With M. Zoran. "Issues and Insights of PSA (Probabilistic Safety Assessment) in Aerospace and Nuclear System Applications." Proc. of ICONE 13 International Conference, Beijing, May 2005.

With J. Railsback et al. "The Space Shuttle Probabilistic Risk Assessment Framework – A Structured Multi-layer Multiphase Modeling Approach for Extremely Large and Complex PRA." Proc. PSAM-7 International Conference, Berlin, Germany, 2004. To appear in *R.E.S.S. Journal*.

With T. Wood. "Defining the Gate-level Importance Measures (GIM) with Extended Sapphire Capabilities in Space Shuttle PRA Quantification." Proc. PSAM-7 International Conference, Berlin, Germany, 2004. To appear in *R.E.S.S. Journal*.

"A Comprehensive and Integrated S&MA Risk-based Management Process – the Triple-Triplets Concept for Managing the STS Safety." NASA Johnson Space Center, SAIC/NC62, January 2004.

With W.E. Vesely. "A Systematic Approach to Identify Candidate Initiating Events for the Integrated Space Shuttle PRA." Proc. International Conference for Technology in Space Operations, Houston TX, USA, May 2002

With W.E. Vesely. "Comparison of Differences and Commonalties of Space Shuttle PRA with Nuclear Plant PRAs." Proc. of PSAM-6, Puerto Rico, June 2002.

With W.E. Vesely and M.A. Ali. "The Indicator Methodology and Software for Monitoring of Failure Dependency." Proc., 5th International Conference on Reliability, Maintainability & Safety. August 2001. Dalin, China.

With W.E. Vesely and M. Stewart. "Human Reliability Analysis Guidelines for the Space Shuttle Probabilistic Risk Assessment." SAIC/NASA, JSC PRA Documentation, April 2001.

With W.E. Vesely et al. "Performance of Integrated Probabilistic Risk Assessment for the Space Shuttle." SPRA Modeling Guidelines, SAIC/NASA, JSC PRA Documentation, January 2001.



Thorsten Ludwig

Dr. Thorsten Ludwig currently works full time as an independent consultant for new energy projects and is involved in projects in Turkey and Germany. He measures energy efficiency and helps in developing promising technologies. He is currently building up an experiment with the Casimir effect in his own laboratory in Berlin. The experiment uses state-of-the-art nano positioning and vacuum equipment to make use of the change in quantum mechanical background radiation.

In 2005 Dr. Ludwig, Marco Bischof, and Andreas Manthey published a study of several new energy technologies for the German government. The study focuses on the use of innovative, unconventional technologies in developing countries. In 2004 he was elected President of the German Association for Space Energy, a nonprofit organisation that promotes the study of the use of energy in space as an energy source. Ludwig runs this association together with his team in Berlin. The association provides members with information and tries to inspire more research and development in this field.

Out of interest in the field of new energy technologies, Dr. Ludwig has participated in a large number of international conferences on future energies and atomic physics, as well as the workshop series QFEXT, which discusses the quantum field theory under the influence of external fields. In this workshop both theoretical and experimental physicists meet to discuss the latest findings around the Casimir effect and its application.

Ludwig worked at the Technical University of Berlin from 1997 to 2005. He received his master's in physics in 2001 and completed his doctor of natural science in 2005, both *summa cum laude*. At the Technical University he also made contact with other scientists and engineers interested in new energy technologies. As a result, a group including Ludwig founded the Berlin Institute for Innovative Energy and Propulsion Technologies in 2001. The institute is committed to gather information, evaluate technologies, and conduct research and development in the field of new energy technologies. The institute has done projects with catalytic hydrogen production, plasma tech, magnetic motors, and solid-state energy conversion.

From 1989 to 1993 Ludwig traveled through South America and Asia, living for two years in Sri Lanka where he learned and practised acupuncture in the government Hospital Colombo South. He also learned the art of meditation in monasteries and from private individuals. To study the observed phenomena he built up a physics laboratory to measure vibrations and magnetic effects of acupuncture and

altered states of consciousness. Back in Germany in 1993 he worked in the cell phone market as a supervisor and group leader, and helped to expand the German company into the Dutch market. His main focus has been to go deeper into new energy technologies that apply totally new concepts and energy sources, as well as include human energy and live forces. Since 1994 he has been determined to unveil new types of propulsion and energy production. His interest was drawn to zero point energy, a sea of energy predicted by quantum mechanics.

Born in Hamburg, Germany, in 1964, Ludwig studied physics and environmental engineering, including nuclear power station technology, in Berlin and Stuttgart. He is a member of the charitable trust INDIACARE, which supports hospitals and solar energy projects in India, and has helped to build the world's largest solar cooker, providing more than 40,000 meals per day.

RECENT, RELEVANT PUBLICATIONS

With Marco Bischof and Andreas Manthey. “Zukunftstechnologien für nachhaltige Entwicklung: Unkonventionelle Ansätze zur Energiegewinnung und Aktivierung biologischer Prozesse.” Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, Bericht E 5001–15, Berlin, 2005.

(Study for the German government on: “Future Technologies for Sustainable Development, Unconventional Methods for Energy Production and Biological Activation.”)

“DVR Besuch bei GIFNET.” DVR-Info Jg. 2, Nr. 5, Okt. 2005.

“Qfext 05 in Barcelona.” DVR-Info Jg. 2, Nr. 5, Okt. 2005.

With M. Busch, R. Drozdowski, and G. von Oppen. “Anticrossing spectra of ^3He and ^4He atoms excited by He^+ -He collisions.” *J. Phys. B: At. Mol. Opt. Phys.*, 39 (8), 28 April 2006, 1929–1935.

With M. Busch, R. Drozdowski, and G. von Oppen. “Anticrossing spectroscopy of He atoms excited by 30–300 keV He^+ impact.” *J. Phys. B: At. Mol. Opt. Phys.*, 37 (14), 28 July 2004, 2903–2915.

“Conference on Quantum Field Theory under the Influence of External Conditions (QFEXT 03).” *NET-Journal* 2003, Heft 09/10, S. 18–19.

With M. Busch, R. Drozdowski, and G. von Oppen. “Paul-trap resonance in He^+ -He collisions.” *J. Phys. B: At. Mol. Opt. Phys.*, 36 (24), 28 December 2003, 4849–4864.

“INE/EEMF-Symposium 2003 in Salt Lake City.” *NET-Journal* 2003, Heft 09/10, S. 20–21.

“Bericht von der ExtraOrdinary Technology Konferenz in den USA.” *NET-Journal* 2003, Heft 09/10, S. 47–50.



John C. Mankins

John C. Mankins is founder and President of ARTEMIS Innovation Management Solutions LLC, a management consulting, research and development start-up focusing on solving innovation challenges for government, industry, and not-for-profit clients. ARTEMIS Innovation provides consulting services to a range of clients, including the Department of Energy (for DOE's Energy Efficiency and Renewable Energy office, both the Solar Energy Technology Program and the Wind Program), the Office of Naval Research, the Applied Physics Laboratory, and a range of other organizations.

Mankins has 27 years of experience involving NASA, the aerospace industry, academia, and the international space community. He is internationally recognized as a successful leader in space systems and technology innovation, and as a highly effective manager of large-scale technology R&D programs. He was one of the creators of the "technology readiness level" (TRL) scale for technology assessment. An acknowledged subject matter expert in these fields, Mankins has testified before Congress on several occasions, and has been consulted on both R&D management and space issues by the General Accounting Office, the Office of the Chief Technologist of the US Navy, the US National Security Space Architect, Japan's Ministry of Economy, and Trade and Industry (METI).

In his most recent position at NASA, Mankins was Manager of the Exploration Systems Research and Technology (ESR&T) Theme within the Exploration Systems Mission Directorate at NASA Headquarters – a key element of the US Vision for Space Exploration. He was responsible for leading and managing an \$800M per year technology R&D program, involving 15 program elements, more than 100 individual projects and organizations, and over 3,000 personnel (inside and external to NASA), including an immediate office staff of some 30 professionals and support staff. During 2004, he was responsible for planning and leading the implementation of two of the largest, most successful technology acquisitions in NASA's history. He had general responsibility for strategy, analyses, planning, organization, budget, acquisition, program management, and reporting in support of future human and robotic space exploration.

Past positions at NASA included Assistant Associate Administrator for Advanced Systems in the NASA Office of Space Flight and Chief Technologist for the Human Exploration and Development of Space (HEDS) Enterprise. For 10 years Mankins was Manager of Advanced Concepts Studies at NASA Headquarters.

He has received numerous awards and honors during his career, including the prestigious NASA Exceptional Technology Achievement Medal (of which he was the first recipient).

Mankins holds undergraduate (Harvey Mudd College, 1978) and graduate (UCLA, 1983) degrees in physics and an MBA in public policy analysis (The Drucker School at Claremont Graduate University, 1986). He has authored or co-authored more than 75 published papers, reports, and other technical documents.

RECENT, RELEVANT PUBLICATIONS

"New Directions for Space Solar Power." 57th International Astronautical Congress (IAC-06-C3.1.3). October 2006.

"Reaching for the Stars: Thoughts Concerning the Past and Future of Interstellar Flight." 57th International Astronautical Congress (IAC-06-D3.2.8). October 2006.

"NASA's Office of Advanced Research and Technology: Introduction and Evaluation of Transitions, 1966–1973." 57th International Astronautical Congress (IAC-06-E4.2.2). October 2006.

With J. Howell. "Modular Reconfigurable High Energy (MRHE) Systems – Stepping Stones to Future Space Activities." 56th International Astronautical Congress, Fukuoka, Japan. October 2005.

With J. Howell. "In Space Cryogenic Fluid Depots – Stepping Stones to Future Space Activities." 56th International Astronautical Congress, Fukuoka, Japan. October 2005.

"Human and Robotic Technology (H&RT) Program Formulation Plan." NASA Office of Exploration Systems. July 2004.

With J. Howell. "Transformational System Concepts and Technologies for Our Future in Space." 55th International Astronautical Congress, Vancouver, Canada. October 2004.

With M. Moffert et al. "Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet." *Science*, 298. 1 November 2002, p. 981.

"Establishing a Biosphere Beyond the Earth: Concepts and Challenges Involved in Developing a Large-scale Habitat on the Moon." 53rd International Astronautical Congress, IAC-02-IAA.13.2.09a, Houston, Texas. October 10–19, 2002.

"The Promise and the Challenge of Space Solar Power in the 21st Century: Picking Up the Gauntlet – The Peter Glaser Lecture for 2002." 53rd International Astronautical Congress, IAC-02-R.1.02, Houston, Texas. October 10–19, 2002.



George E. Mueller

Dr. George E. Mueller is the former head of the NASA Apollo project. Mueller led the program that put Americans on the Moon less than seven years after he took over the enterprise. In 1963 Dr. Mueller was asked by the NASA Administrator to lead the manned space flight program, where he was responsible for the Gemini, Apollo, and Saturn projects. The Kennedy Space Center, Marshall Space Flight Center, and Johnson Space Center reported to him. From the beginning of Gemini flight operations in 1963 through the second Apollo Moon landing in 1969, he directed the US manned flight program.

His leadership made possible the achievement of the national goal set in 1961: the landing of men on the Moon and their safe return to Earth by the end of the decade. To accomplish this goal, he merged the diverse activities of academia, industry, and NASA into a concerted effort, and to direct this effort, developed one of the most sophisticated and successful management systems ever devised. Throughout the good and the bad days of the Apollo Program, George Mueller inspired industry, NASA, the citizenry, and the legislative and executive branches of the government to overcome adversity and meet the challenge of the Apollo Program.

George Mueller was also the originator of Skylab, the world's first space station, and the “Father of the Space Shuttle.” He is the author of the post-Apollo plan, “An Integrated Program of Space Utilization and Exploration,” which has been the guiding document

for NASA for the past several decades.

Dr. Mueller has also served as Senior Vice President of the General Dynamics Corporation (1969–1971) and as Chairman and President of System Development Corporation, a developer of software systems for the US Air Force (1971–1983). He has served as both CEO (1995–2003) and Chairman (2003–2006) of Kistler Aerospace Corporation.

He is a member of numerous professional organizations including the National Academy of Engineering, the American Association for the Advancement of Science (of which he is a Fellow), the American Geophysical Union, the American Astronautical Society, the Institute of Electrical and Electronics Engineers, the Royal Aeronautical Society, and the French Academy of Astronautics. He is an honorary Fellow of the American Institute of Aeronautics and Astronautics, and of the British Interplanetary Society. He is Past President of the International Academy of Astronautics.

Mueller has received honorary doctorates from six universities. His numerous awards include three NASA Distinguished Service Medals, the American Astronautical Society Space Flight Award, the Eugene Sanger Award, the Yuri Gagarin Space Award, and the Goddard Award from the American Institute of Aeronautics and Astronautics. He was awarded the National Medal of Science for his many individual contributions to the design of the Apollo system, including the planning and interpretation of a large array of advanced experiments necessary to ensure the success of this venture into a new and unknown environment.



Fabrizio Pinto

Dr. Fabrizio Pinto is President and CEO of InterStellar Technologies Corporation, headquartered in Monrovia, California. He obtained his *Laurea* in physics *cum laude* at the University of Rome, La Sapienza, in 1984 with a thesis on globular star cluster formation. He moved to the United States in 1986 and obtained his Ph.D. at Brigham Young University in Provo, UT, with a Sigma-Xi award-winning dissertation on the dynamics of globular clusters in the protogalactic halo, in 1989. He has held positions at Ricks College, Boise State University, Oregon State University, and Portland State University.

From 1996 to 1999, Dr. Pinto was a scientist in the Navigation and Flight Dynamics Section of the Jet Propulsion Laboratory at CalTech. While at JPL, he participated in navigation and orbital dynamics activities for the Stardust, Deep Space 1, and Galileo missions. He also contributed as a navigator to the exploratory panel studying the feasibility of the Interstellar Space Probe and was a senior astrophysics lecturer at the University of Southern California in the 1998–99 academic year. Since 1999, Dr. Pinto has been the President and CEO of InterStellar Technologies Corporation, a privately held company he founded to bring profitable quantum vacuum engineering technologies to the international marketplace. The company holds an ever-growing intellectual property portfolio in the United States and abroad, actively pursues both theoretical and experimental R&D at its facilities, and has published several award-winning

articles in the field. For more information on Dr. Pinto, the company, and the physical principles behind quantum vacuum engineering, visit www.interstellartechcorp.com.

RECENT, RELEVANT PUBLICATIONS

“Discrepancy between published Laplace difference equations on cylindrical dielectrics.” To appear in the *Am. J. Phys.* 2007.

“A trapped dipolar BEC interferometry test of $E=mc^2$.” *Int. J. Mod. Phys. D.*, 15 (12), 2006.

“Progress in quantum vacuum engineering propulsion.” *JBIS*, 59, 2006, 247–256.

“Resolution of a paradox in classical electrodynamics.” *Phys. Rev. D.*, 73, 2006, 104020.

“Analytical and experimental investigation on a vibrating annular membrane attached to a central free, rigid core.” *J. Sound Vib.*, 291, 2006, 1278–1287.

“Self-coupling of excited atoms in curved spacetime.” *Int. J. Mod. Phys. D.*, 14 (12), 2005, 2271–2277.

“Van der Waals forces in curved space as a quantum tool to test general relativity theory.” *Int. J. Mod. Phys. D.*, 14 (6), 2005, 995–1008.

“Computational considerations in the calculation of the Casimir force between multilayered systems.” *Int. J. Mod. Phys. A*, 19 (24), 2004, 4069–4084.

“Casimir force between a gravitational field and a finite object.” *Int. J. Mod. Phys. D.*, 11 (10), 2002, 1567–1572.

“Engine cycle of an optically controlled vacuum energy transducer.” *Phys. Rev. B*, 60 (21), 1999, 14740–14755.



Darel Preble

Darel Preble is a systems analyst, physicist, and, since 1997, Chair of the Space Solar Power Workshop. He incorporated the Space Solar Power Institute as a 501(c)3 corporation in 1997. In 1994, 1995, and 1996, while employed as Southern Company’s Nuclear Security Analyst, he wrote (not at Southern Company’s request or expense) three annual white papers entitled “Solar Power Satellites (SPS): The Technological Imperative?” These were circulated within the electric power industry and aerospace community.

Preble was previously Senior Systems Analyst for INCORE, a nuclear class 1 (safety related) IBM mainframe computer code that managed the nuclear burn at Southern Company’s PWR nuclear reactors. This system of Fortran programs was/are audited annually for adherence to INPO (Institute of Nuclear Power Operations), Southern Company, FERC, and other nuclear standards-making bodies, both internal and external. During this time he isolated and documented multiple errors in IBM’s mainframe Fortran compilers, which he worked with IBM to rectify. Prior to his arrival nuclear audit “findings” were a chronic problem area; during his tenure nuclear audit findings were eliminated. He improved V&V nuclear software acceptance standards by a factor of ten. Among other achievements, Preble created, taught, and hired teachers for classes in new technology systems including neural networks and genetic algorithms; initiated and led numerous advanced technology development projects including an advanced weather forecasting evaluation for bulk power marketing; and represented Southern Company at numerous power industry conference and computer forums including EPRI, EEI, and INFORUM.

Preble’s first published testimony before the Department of Energy for the “Third Energy Plan,” 1980, “Solar Power Satellites – Energy for the Future” was read into the Congressional Record for June 22, 1981. In 1983 and 1984, he organized and moderated Space Week Symposiums through Georgia State University’s Continuing Education Department. Doing this enabled him to meet Dr. Peter Glaser, who patented the SSP concept and other notable lecturers, including Dr. Gerard O’Neill, founder of the Space Studies Institute.

Preble organized, directed, and moderated “The Great Debate” at the Space 2000 ASCE Aerospace Conference, March 18, 2000, in which two teams of internationally recognized experts debated the resolution that the focus of human space exploration beyond the ISS should be (a) the Moon or (b) Mars. Video publication and production were by ASCE and NASA Glenn Research Center (GRC-401).

With the thesis “Shell Model Calculation of the Splitting between the T=0 and T=1 6 States of Silicon 28 (Nuclear modeling),” Preble earned a master’s in physics from Georgia State University. He also holds a master’s in administration (systems management) from George Washington University, where his thesis was on research and development forecasting. His bachelor’s in physics is from Vanderbilt University. He is a member of the Board of Directors of the National Space Society and a member of the National Defense Industries Association Energy Security Committee, IEEE, Sigma Xi, and SSI.

RECENT, RELEVANT PUBLICATIONS

The Space Solar Power Workshop website <http://www.sspi.gatech.edu/> contains chapters intended to establish a conceptual design of why and how to build, finance, deliver, market, support, operate, and maintain an SSP System. Chapters Preble has written include “Space Transportation,” “Photovoltaics,” “Climate Change Weather Impacts,” and “Draft Legislation for a Sunsat Corporation.” Other authors are working on the “Wireless Power Transfer” chapter.

“A Clean, Safe and Reliable Baseload Power.” Plenary speaker, Proceedings of 3rd International Symposium for 21 COE Sustainable Energy Systems, Kyoto University, Japan, August 30, 2006. <http://energy.coe21.kyoto-u.ac.jp/eng/index.html>. Presentation at http://www.sspi.gatech.edu/clean_baseload_energy.ppt.

“NASA – Wrong mission for the Right Stuff.” *EnergyPulse*, June 20, 2006. http://www.energypulse.net/centers/article/article_display.cfm?a_id=1285.

“SunSat Corporation, a public/private corporation for Space Solar Power.” Proceedings of the Japanese SPS Research Society 8th Symposium, Teikyo University, Japan, September 16, 2005. Conference video at <mms://science4.dvrdns.org/8th-SPS-Sympo-Preble>.

“AQUAPLEX: An Environmentally Aware Model Lunar Settlement.” Proceedings of 2003 STAIF Aerospace Conference, February 2003.

“The Space Solar Power Corporation Act (Sunsat Act).” Proceedings of 2002 ASCE Aerospace Conference, March 18, 2002.

“A Space Solar Power Workshop (SSPW).” 2001 IEEE Aerospace Conference, March 14. Paper 12.0502. <http://www.aeroconf.org/>.

“Research Issues in Space Macrosystems: Autonomous Construction and Manufacturing for Space Electrical Power Systems.” Proceedings of NSF/NASA workshop, April 5–7, 2000.

“A Space Solar Power Workshop, Collaborative Systems Development on the Internet.” Proceedings of Space 98, ASCE Aerospace Conference, April 26–30, 1998.



Crispin Tickell, GCMG KCVO

Sir Crispin Tickell is the Director of the Policy Foresight Programme at the James Martin Institute for Science and Civilization at Oxford University. Other significant current appointments include Chairman of the Trustees of the St. Andrew's Prize for the Environment, a position he has held since 1998, and Advisor at Large to the President of Arizona State University, which he has continued since 2004. His main interests are in the field of the environment and international affairs.

Most of Tickell's career has been in the Diplomatic Service. He was Chef de Cabinet to the President of the European Commission from 1977 to 1980, Ambassador to Mexico from 1981 to 1983, Permanent Secretary of the Overseas Development Administration from 1984 to 1987, and British Permanent Representative to the United Nations from 1987 to 1990. He then became Warden of Green College, Oxford, a position he held from 1990 to 1997, and he was Chancellor of the University of Kent from 1996 to 2006. Among other positions he was also President of the Royal Geographical Society from 1990 to 1993, Chairman of the Board of the Climate Institute of Washington, DC, from 1990 to 2002, Convenor of the Government Panel on Sustainable Development from 1994 to 2000, a Trustee of the Baring Foundation from 1992 to 2002, Inaugural Senior Visiting Fellow at the Harvard University Center for the Environment from 2002 to 2003, and Advisor-at-Large to the President of Arizona State University from 2002. Since 1992 he has been a member of the China Council for International Cooperation on Environment and Development.

Tickell was a member of two Government Task Forces: one on Urban Regeneration (1998–1999); the other on Potentially Hazardous Near Earth Objects (2000). From 1999 to 2004, he was a member of the Oxford Commission on Sustainable Consumption, and from 1994 to 2000, he served on the Government Round Table on Sustainable Development. He was a part of the Committee for the Public Understanding of Science (COPUS) from 1991 to 1994, and of the Working Group on the Use of Non-Human Primates in Research, 2005 to 2006. Since 2002, he has served on

the Board of Overseers of the International Research Institute for Climate and Society at the Earth Institute, Columbia University, New York. His interests range from business and charities to climate, pre-Columbian art, and the early history of the Earth.

Among many honours and distinctions Tickell has received are the GCMG (Grand Cross of the Order of St. Michael and St. George) in 1988, KCVO (Knight Commander of the Royal Victorian Order) in 1983, and MVO (Member of the Royal Victorian Order) in 1958. He received the Chinese Government Friendship Award in 2004, the Award for International Cooperation on Environmental Protection (Chinese State Environmental Protection Agency SEPA) in 2003, Distinguished Environmental Lecturer at Harvard University in 2001, Melchett Medallist of the Institute of Energy in 1996, and Global Environmental Leadership Award of the Climate Institute of Washington, DC, in 1996. Eight institutions have named him an Honorary Fellow and twenty-four honorary doctor degrees were conferred upon him between 1983 and 2006.

RECENT, RELEVANT PUBLICATIONS

Climate Change and World Affairs. Harvard University, 1977; Pergamon Press, 1978. Revised edition, Harvard University and University Press of America, 1986.

Mary Anning of Lyme Regis. Lyme Regis Museum, 1996, 1998, and 2003.

Contributor to *Scientists Debate Gaia*. Edited by Stephen H. Schneider, James R. Miller, Eileen Crist, and Penelope J. Boston. 2004.

Contributor to *Johannesburg Summit 2002: Challenges and Partnerships*. Edited by Diana Fortescue. 2002.

Contributor to *Managing the Earth*. Edited by James C. Briden and Thomas E. Downing. 2002.

Contributor to *The Changing World*. Edited by Patricia Fara, Peter Gathercole, and Ronald Laskey. 1996.

Contributor to *Science for the Earth*. Edited by Tom Wakeford and Martin Walters. 1995.

Contributor to *Sustainable Development and the Energy Industries*. Edited by Nicola Steen. 1994.

Contributor to *Monitoring the Environment*. Edited by Bryan Cartledge. 1992.

Contributor to *Sustaining Earth: Response to the Environmental Threats*. Edited by David J.R. Angell, Justyn D. Comer, and Matthew L.N. Wilkinson. 1990.



Thomas F. Valone

Thomas F. Valone, Ph.D., P.E., physicist, and licensed professional engineer with 30 years' professional experience, is a patent examiner, research engineer, instrumentation designer, and also an author, lecturer, and consultant on future energy developments. He is President and founder of Integrity Research Institute and formerly a community college teacher and a Research Director for Scott Aviation-ATO, Inc.

Valone helped design the HullCom® for naval intraship communication, a 60 Hz gaussmeter without harmonic distortion, two bioelectric therapy devices, and a dental mercury vapor ionizer-precipitator. He is Editor of *Future Energy*, *Energetic Processes Vol. I & II*, *Turning the Corner: Energy Solutions for the 21st Century*, and a few conference proceedings, as well as author of *Practical Conversion of Zero-Point Energy*, *Homopolar Handbook*, *Electrogravitics Vol. 1 & II*, *Bioelectromagnetic Healing*, *Bush-Cheney Energy Study*, *Clinton Administration Energy Study*, and about 100 published reports and articles. He has also served as an expert witness and an expert declaration writer for court cases, and has appeared on CNN, A&E, and the Discovery Channels, besides a few commercial energy videos.

Currently, Dr. Valone is a member of the Institute of Electrical and Electronic Engineers, the Bioelectromagnetics Society, the National Space Society, and the Union of Concerned Scientists. He is also a Fel-

low of the World Innovation Foundation. His works have been published in German, French, Korean, and English.

RECENT, RELEVANT PUBLICATIONS

“Energy in Your Future.” Bimonthly column in *Infinite Energy Magazine*. 2006 to present.

“Progress in Future Energy Technology.” Proceedings of the 2nd International Conference on Future Energy, 2006.

Electrogravitics II: Validating Reports on a New Propulsion Methodology. Integrity Research Institute, 2004. ISBN 0-9641070-9-0.

Practical Conversion of Zero-Point Energy. Integrity Research Institute, 2003. ISBN 0-9641070-8-2.

“Feasibility Study of Zero-Point Energy Extraction from the Quantum Vacuum for the Performance of Useful Work.” (Ph.D. Thesis) 2003.

“Future Energy Technologies.” *New Energy Technologies*, 1 (4), January–February 2002, p. 23.

Harnessing the Wheelwork of Nature: Tesla's Science of Energy. Adventures Unlimited Pub., 2002. ISBN 0-931882-04-5.

Editor. *Energetic Processes: The Interconnection of Matter, Energy, and Consciousness, V. 1*. Xlibris Publishers, 2002. ISBN 0-4010-4113-2.

Editor. *Future Energy*, 1 (1–4), 1999–2003; *Future Energy Annual*, 2004.

“Unusual Permanent Magnet Motors,” *J. of New Energy*, 6 (2), 2001.

