THE FUTURE OF SCIENCE™

THIRD WORLD CONFERENCE

The Energy Challenge

VENICE, SEPTEMBER 19 - 22, 2007

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Fondazione Giorgio Cini,
Island of San Giorgio Maggiore.

We are pleased to welcome you to the Third World Conference on the Future of Science. This year's theme - The Energy Challenge - pertains directly with an important declaration of the Venice Charter (strategic document for the Future of Science programme) that "applied research must be concerned with goals that are essential for the future of humanity, including improvement of energy efficiency and reduction of fossil fuel use".

The Conference starting point is a proposition on which almost everyone now agrees: fossil fuels can no longer be the mainstay of humanity's energy supply.
However the search for alternative energy sources cannot be left to science and industry alone, but must involve the whole of society because the choices are momentous and the political and ethical implications far-reaching.
It will be necessary to strike balances between impacts on productivity and the environment and to manage the economic and social costs.

To successfully move away from fossil fuel dependence we need to free ourselves from outmoded ideological baggage, and the vested and local interests that suffocate innovation in energy policy.

It will also be necessary to make the universal, objective and future-orientated voice of science heard as never before; this may be achieved, as the Venice Charter affirms, by actively reasserting the humanism of science, its intrinsic spirit of tolerance, and its incompatibility with absolutism of all forms.

In welcoming you, we also thank you - speakers and participants from all over world - for choosing to come to Venice and contribute to this ambitious project.

Umberto Veronesi
Conference President

Chiara Tonelli
Conference Secretary General

PRESIDENT
Umberto Veronesi.

VICE PRESIDENT
Kathleen Kennedy Townsend.

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MEDIA RELATIONS
Donata Francese.

Opening Ceremony.

The opening ceremony at the Cini Foundation, Island of San Giorgio Maggiore, will provide an opportunity to outline the main problems constituting The Energy Challenge.

The speakers will develop their views on how the Energy Challenge will impact society and culture, politics and economics, and the health of the planet and its human inhabitants - in the key of the Venice Charter declaration that major goals of applied scientific research must include reduced use of fossil fuels and expanded use of alternative energy sources.

In line with the aims of the Future of Science Programme, The Energy Challenge theme is one that brings science back to the centre of public attention and debate.

h. 6.00 p.m.

Umberto Veronesi, President
of the Third World Conference of The Future of Science
"The energy challenge as a cultural challenge"

Giovanni Bazoli, President of the Giorgio Cini Foundation
"The energy challenge: at the core of the debate
between science and society"

Marco Tronchetti Provera, President
of the Silvio Tronchetti Provera Foundation
"Energy and the environment: challenges
and responsibilities for companies and consumers"

Kathleen Kennedy Townsend, Vice President
of the Third World Conference of The Future of Science
"The political challenges of the energy problem"

Chiara Tonelli, Secretary General
of the Third World Conference of The Future of Science
"Third World Conference on the Future of Science:
the energy challenge"

Carlo Rubbia, Nobel Laureate in Physics
"The importance of discussion about big ideas in science"

Energy: present and future sources.

It is vital to have the means to assess the environmental, social and economic impacts of different approaches to energy production and storage for the future. In this session various energy sources will be surveyed, including nuclear fission, nuclear fusion, fossil fuels, plant biomass, solar energy and geothermal energy, and their possible roles in a future sustainable energy scenario examined.

h. 9.00 a.m. - 1.00 p.m..

Chairs: **Paolo Milani** and **Enrico Bellone**

Peter Atkins
The nature of energy

János Béer
Fossil fuel based power generation in a carbon constrained world

Maurizio Cumo
Nuclear Fission: present and future

Stephen Connors
Large-scale introduction of renewables: designing for the dynamics

Michael Bevan
Plant biomass for sustainable fuel production

Panel Discussion

h. 2.00 p.m. - 6.00 p.m.

Chairs: **Renato Angelo Ricci** and **Peter Atkins**

Carlo Rubbia
Innovation: the key to future renewables

Zhores Alferov
Is solar energy conversion an option
to solve the energy problems in future?

Louis Schlapbach
New materials for energy technologies

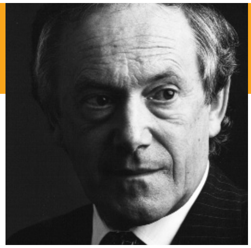
Jefferson Tester
The future of geothermal energy as a sustainable pathway

Jeffrey Byron
The many faces of energy efficiency

Panel Discussion

h. 8.00 p.m.

Concert at Scuola Grande di San Rocco



Peter Atkins
Professor of Chemistry, Oxford University

Peter Atkins began his academic life as an undergraduate at the University of Leicester, and remained there for his PhD. He then went to the University of California, Los Angeles as a Harkness Fellow and returned to Oxford as lecturer in physical chemistry and fellow of Lincoln College in 1965, where he has remained ever since, now as professor of chemistry. He has received honorary doctorates from universities in the United Kingdom (Leicester), the Netherlands (Utrecht), and Russia (Mendeleyev University, Moscow) and has been a visiting professor at universities in France, Japan, China, New Zealand, and Israel.

His research was in the application of quantum mechanics to chemical problems and theoretical aspects of magnetic resonance, but with time he drifted into writing books, which now number about 55. The best known of these is Physical Chemistry, now in its eighth edition; that text became an instant best-seller when it was first published in 1978 and has remained that ever since; it is used throughout the world and has been translated into many languages. His other major textbooks include Inorganic Chemistry, Molecular Quantum Mechanics, Physical Chemistry for the Life Sciences, Elements of Physical Chemistry, and various flavours of General Chemistry. He also writes books on science for the general public, including The Periodic Kingdom, The Second Law, and Creation Revisited. One of these books, Molecules, was described as 'one of the most beautiful chemistry books ever written'. A recent book for general audiences is Galileo's Finger, which gives an account of his selection of the ten great ideas of science

In his spare time he is deeply involved in a variety of international activities, including (until the end of 2005) chairing the Committee on Chemistry Education of the International Union of Pure and Applied Chemistry - the governing body of the subject - which has the task of improving chemical education worldwide, especially in developing countries, and encouraging and coordinating international efforts towards the public appreciation of chemistry. He also helps to organize the Malta series of conferences, which bring together chemists from the Middle East.

Abstract

The nature of energy.

Energy is one of the most elusive concepts in science. In this introductory talk I shall present various aspects of energy so that we can build up a variety of perspectives on to this highly abstract but hugely important concept.

Energy is a recent entry into the vocabulary of science, and can be traced to a remark made by Thomas Young in 1807. Before that, the principal concept of discourse in physics had been the much more tangible concept of force. Indeed, Newton did not use the term energy in the whole of his formulation of classical mechanics, basing it on 'force' and its consequences. The extraordinary potency of the concept of energy soon became apparent, and had moved to centre stage by the middle of the nineteenth century. Then, with the formulation of thermodynamics, the concept of energy was extended to embrace the concept of heat. The twentieth century saw two extraordinary developments of the concept, one was the quantization of energy, the realization that energy could be transferred to a system only in discrete packets, and the other was its role in Einstein's theory of relativity and the realization that mass is a measure of energy, with correspondingly enormous consequences for the production of energy by fission and fusion and political implications of the highest order. Even in the twenty-first century, the concept of energy has not lain asleep, for it is a crucial part of our understanding of the inception of the universe and, through the cosmological constant, its long-term distant future. In this talk, I shall prepare the ground for the following talks by reviewing this history and identify the changing aspects of the central concept of this meeting; energy.

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But what is energy? I shall develop the concept so that we can begin to grasp its meaning. The simplest definition of energy is that it is the capacity to do work. And what is work? Work is done when a body is moved against an opposing force, such as raising a weight against the force of gravity. I shall give a number of examples to make clear this central connection between the tangible, older, more primitive concept of force and the more abstract, newer, more sophisticated concept of energy.

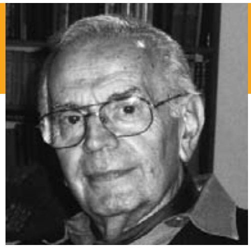
Then we have to understand that there are two ways of increasing the energy content of a system or extracting the energy that is present: one is to transfer the energy as work and the other is to transfer the energy as heat. A great clarification of the nature of work and heat stems from the interpretation of the two concepts in terms of the atomic processes involved, and I shall elucidate this point. One interesting feature that will become apparent is why the extraction of energy as work through the agency of an engine came much later in the history of civilization than the extraction of energy as heat and this point will elucidate why scientists and engineers are still evolving methods of obtaining useful energy for manufacture, transport, and communication.

This feature - the relative ease with which energy can be extracted as heat compared with work - leads directly to the important realization that there are two aspects of energy that we must keep in mind throughout the coming presentations: we have to consider both its quantity and its quality. The first law of thermodynamics essentially states that the total quantity of energy is constant. That is true of a tiny isolated system and also of the universe as a whole. Therefore, there is no such thing as an 'energy crisis' because there is no way of destroying energy! An incidental point is how much energy there is in the universe, and therefore how much had to appear when the universe first emerged from nothing.

Abstract

I shall touch on this point. The second law of thermodynamics, however, essentially says that the quality of energy is ceaselessly degrading. I shall give a pictorial interpretation of the second law and introduce entropy, the measure of the quality of stored energy. In fact, the world is faced with an entropy crisis, not an energy crisis, so it is important to understand this concept. I shall show that, despite its reputation, the concept of entropy is in fact much easier to understand than the concept of energy itself, and show how the second law accounts for the occurrence of all change, from the combustion of a fuel to the formation of a thought.

As we listen to the following lectures, we should keep all these points in mind, for they will be developed throughout this meeting. The following lectures will touch on all aspects of this crucially important concept, from its capture from sunlight, through its implications for the environment, and to the politics of sustainability. No other concept touches so closely our fundamental nature and our everyday interactions with our surroundings and each other.



János Miklós Beér

Professor Emeritus of chemical and fuel engineering at MIT

He was born in Budapest in 1923, took a Diploma in Engineering from Budapest Technical University, and after working at the Heat Research Institute, Budapest, moved to Scotland in 1956 as a research engineer for Babcock & Wilcox. He then became a research fellow at Sheffield University, gaining his PhD in 1960. After spells as head of the International Flame Research Station, IJmuiden, Netherlands, and professor of fuel science at Penn State University, he returned to Sheffield as professor and head of the Department of Chemical Engineering and Fuel Technology. He was Dean of Engineering at Sheffield from 1973 to 1975. He moved to MIT in 1976, as professor of chemical and fuel engineering, and director of the Combustion Research Facility.

Professor Beér has made pioneering contributions to combustion science and the technology of coal, oil, and gaseous flames. His work led to commercial burners that control fuel/air ratio and temperature during combustion to minimize NOx emissions yet maintain high combustion efficiency. He has received numerous awards for his achievements including: British Coal Utilization Research Association, Coal Science Gold Medal, 1986; Axel Axelson Johnson Medal, Royal Swedish Academy of Engineering Science, 1995; Honorary Doctorate, Budapest Technical University, 1997; American Institute of Aeronautics and Astronautics Energy Systems Award, 1998; and Homer Lowry Gold Medal, US Department of Energy, 2003.

Professor Beér believes that coal and natural gas will continue to furnish most of mankind's electrical energy for some time to come, so it is imperative to refine combustion technology to further increase efficiency and lower pollutant emission. He believes that high efficiency combined with carbon capture and sequestration will lead to a near zero emission coal plant.

Abstract

Fossil fuel based power generation in a carbon constrained world.

Fossil fuels ,especially coal and natural gas (NG) will continue to play major roles for the future in electric power generation world wide; coal ,because of its low cost, broad availability with large reserves over the world , and natural gas ,a premium fuel with no ash ,no sulfur or mercury content and of low C/H ratio, that makes its utilization capable of low CO2 emission. High efficiency power generation combined with carbon capture and sequestration (CCS) is the long term technology objective leading to the Near Zero Emission coal plant. In the interim, before CCS becomes commercial, new plants can be built with the highest thermal efficiency that is economically justifiable, to reduce pollutant and GHG emissions.

For Rankine thermodynamic cycle plants higher efficiency means advanced steam parameters of elevated pressure, superheat and reheat temperatures; for natural gas combined cycle (NGCC) Brayton/Rankine thermodynamic cycle plants increased gas turbine firing temperatures and sequential combustion, and for coal gasification combined cycle (IGCC) improved gasification technologies suitable for a wide range of coal qualities and gas turbines capable of burning syngas with high hydrogen concentration all in increased operational availability of the plant.

Performance characteristics and costs of clean coal technology options are discussed with special reference to information from the recently released MIT Study: The Future of Coal.

Maurizio Cumo
Department of Nuclear Plants, La Sapienza University, Rome, Italy

He is eminent for his fundamental research on heat and mass transfer in the conditions occurring in nuclear reactors, and for the design and safety of nuclear reactors and their components. He has worked on the design of second-generation nuclear fission reactors, including safety systems that operate without the need for energy input or the intervention of operators). He is involved in the Multipurpose Advanced Reactor Inherently Safe (MARS) project which proposes small-size, easy to assemble and disassemble, nuclear reactors that generate heat as well as electricity, and are characterized by multiple intrinsic and passive safety features.
In addition to his work as academician and researcher, Professor Cumo is active in areas of policy and administration in Italy and abroad. For example he is member of the High Risks Commission of the Italian Prime Minister's Office, concerned with industrial, nuclear and chemical risks; chair of the Safety Board concerned with the feasibility study for Units 3 and 4 at the Mochovce Nuclear Power Plant in Slovakia; and president of the Italian Nuclear Power Plant Management Company (SOGIN) which, with a workforce of 630 and budget of 2.5 billion US$, is decommissioning the four Italian nuclear power stations.
Awards and prizes include the 1994 Italgas International Prize for energy, the Luikov Medal for achievement in research of fluid mechanics and thermodynamics, the Order Of Merit of the Italian Republic and Knight, Great Cross of the Order of Merit of the Republic of Italy (2006).

Abstract

Nuclear Fission: Present and Future.

An outline of nuclear power plants at world level opens the presentation, addressing also to future programs of major countries. In this context research developments for reactors, nuclear fuels, reprocessing plants, nuclear wastes and repositories, particularly in European Union and USA, are discussed.
Present researches are concentrated in two groups, one at short and medium term for a reactors' generation denoted with III+ and a second one at long term, which means 2030 for commercial start-up, characterized as "Generation IV".
In the first group researches are concentrated on life extension of reactors and on maximising the energy outputs of their fuels, which means the increase of burn-up up to sixty GWd/ton and more.
In USA almost one half of the 103 reactors in operation have been authorized by the control authority NRC to prolong their licences of 20 years, and the remaining ones will follow.
There is an increasing tendency in the world to adopt the closed fuel cycle with reprocessing of exhausted fuel and recovery of uranium and plutonium for their recycling in the form of mixed oxydes fuels.
The problem of wastes is extensively treated for short life and very long life ones.
In European Union these nuclear wastes increase at a rate of 40.000 m3 per year.The long life wastes, which presently totalize 17.500 t, have an annual production of 1.730 t. The wastes coming from the two reprocessing plants of La Hague in France and Sellafield in U.K. have reached a volume of 6.000 m3, which increases now at a rate of 240 m3/year.

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Abstract

Ad hoc researches are performed for the best solutions of surface repositories for low and medium activity wastes of short life and for geological repositories, for long life wastes. The firs ones may serve also for interim storage of long life wastes, which was originally conceived for a period of 50 years of cooling and now, from the results of these researches, seems may be extended up to some centuries, allowing more time for the deployment of geologic repositories, well certified and retrievable for a convenient period. For this type of repositories, in EU, between 1990 and 1995 the Sweden has built in ASPO the Hard Rock Laboratories, a vast complex at 460 m of deepness in granite, a rock whose only 2 m. may block the most penetrating radiations.
In Finland, after a long popular consult, the decision has been taken to site a geologic repository in Holkiluoto. Its construction will start in 2010 and will be completed in 2020.
30 years after, at the light of then available technologies, the decision will be taken if this repository will be, or not, definitive.
To reduce greatly the problem of nuclear wastes an important line of research has been undertaken with a sharp separation , in the reprocessing, of long life radionuclides such as the minor actinides rutenium, cesium and neptunium and a few fission products like I 129 and tecnetium 99.
Once separated, these radionuclides will be irradiated in a fast neutronic spectrum and transmutated in short life nuclides.

To make this job, we need fast reactors of the fourth generation or special devices called ADS (Accelerated Driven Systems), which consist in a protons accelerator, coupled with a subcritical fast reactor.
The French, in their Atalante experimental plant, have demonstrated the possibility of the separation of the minor actinides and have furtherly irradiated them for transmutation in their Phenix reactor. The whole process, scientifically ascertained, is now developed to evaluate the feasibility of its evolution to an industrial scale.
In European framework Program VI a research program, called EUROTRANS, has been initiated to evaluate experimentally the nuclear transmutation.
Coming to USA, the Department of Energy has devoted an important research program on the nuclear fuel cycle for the short term (Advanced Fuel Cycle Initiative, AFCI I) and the medium term (AFCI II).

Abstract

With AFCI I the USA re-open the activities on closed nuclear fuel cycle, aiming at a strong reduction of the volume of their nuclear wastes to be inserted in geological repositories.
Up to now they have accumulated 44.000 metric tons of exhausted fuels distributed in all their commercial nuclear reactors, with a production of 2000 tons of exhausted fuel every year. At this rate, the available volume of their geological repository of Yucca Mountain, if finally certified, should be filled in the year 2015.
After September 11 2001, it is obviously much better to concentrate underground the exhausted fuel instead of leaving it in so many dispersed localities. More, if the 440 tons of plutonium in the exhausted fuel might be recovered in a reprocessing plant and recycled in the present american reactors as MOX fuel, all the plants might produce energy for four years and half.
In the meantime in USA an experimental reprocessing technique called Uranium Extraction Technology, UREX, has shown, with tests performed at the Savannah River Technology Centre the ability to recover uranium from the exhausted fuel in the amount of 99,9%.
The American research program, strictly connected with the development of Generation IV reactors has the following tasks:

- to reduce the volume of high activity wastes;
- to increase the capacity of Yukka Mountain repository;
- to reduce the amount of the plutonium in the exhausted fuel;
- to recover energy form the exhausted fuel;

and, for the long term:

- to reduce the radiotoxicity of the exhausted fuel;
- to reduce in it the generation of heat at long term;
- to produce fuel for future Generation IV reactors.

Further researches will be performed at the high flux isotope reactor of the Oak Ridge National Laboratory and the advanced test reactor of the Idaho National Engineering and Environment Laboratory (INEE).

The presentation is extended also to the main researches performed in joint programs of the OCSE countries.

Stephen Connors

Director of the Analysis Group for Regional Energy Alternatives (AGREA)
at MIT's Laboratory for Energy and the Environment

AGREA's primary research focus is strategic planning in energy and the environment, with emphasis on the transformation of regional energy infrastructures.
Fundamental to AGREA's approach is the use of long-term planning tools within a multi-attribute tradeoff analysis framework, a framework that involves automatic searching for cost-effective ways to attain multiple goals of cost-competitiveness and environmental quality, and encouraging public participation in planning via stakeholder interaction.
AGREA is currently focusing on how to incorporate daily and seasonal variations of renewable energy resources, as well as energy efficiency options, into the design of robust, cost-effective energy strategies. Wind, solar and biofuel energy sources reduce greenhouse gas emission and fossil fuel dependency, but introduce other uncertainties. These aspects of future energy options are being included in strategic planning and outreach activities.
Stephen Connors also coordinates international energy initiatives involving MIT, including the ALLIANCE FOR GLOBAL SUSTAINABILITY's Near-Term Pathways to a Sustainable Energy Future research, education and outreach program, and the Sustainable Energy Systems Focus Area of the MIT-PORTUGAL PROGRAM. He is former head of the MIT ENERGY LABORATORY's Electric Utility Program, and holds two degrees from the UNIVERSITY OF MASSACHUSETTS in Amherst (Mechanical Engineering and Applied Anthropology), and a masters from MIT (Technology and Policy). Stephen was sometime Peace Corps volunteer in Benin, working on the design and testing of wood-conserving cookstoves. He is also active in several Boston area initiatives to promote energy conservation, renewable energy, and sustainable transportation.

Abstract

Large-scale introduction of renewables: designing for the dynamics.

Whether through emissions trading, renewables obligations or biofuel targets, governments big and small are expecting renewable energy resources to become a large portion of our future energy mix. However, renewable energy technologies and resources are inherently different from today's primary energy carriers dependent on fossil fuels. Whether solar, wind, biomass or hydropower—to name just a few, the daily, seasonal and even inter-annual dynamics of renewable resources impact both the cost-effectiveness of these alternatives, as well as their ability to reduce greenhouse gases and other pollutant emissions. As such, investments are needed not only to improve renewable energy technologies, but to understand the coupled dynamics of renewable energy resources, diverse energy storage technologies (including hydrogen), as well as the dynamics of energy demand and the operation of fossil power generation and fuel production. This knowledge is essential, especially for renewable power generation, as the timing of renewables affects whether a dirty and/or expensive kWh of fossil generated energy is displaced.
The shift from a fossil-based energy infrastructure, to one which maximizes the use of local and regional renewable resources, also represents a shift from centralized production and distribution of energy, to a very dynamic and distributed set of energy technologies. Therefore, policies which call for the large-scale introduction renewables must also invest in developing the "situational" information regarding local supply and demand dynamics. Much of this can be extending the range of information already collected by governmental meteorological and agricultural agencies, as well as the energy companies that run the power network.

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Abstract

While much of the debate over renewables as focused on power generation, the role of renewables–biomass in particular-to displace fossil fuels in transportation and in stationary applications as a thermal fuel, should not be overlooked. Nor should the need for a new generation of energy professionals, with knowledge and skills focused on the future rather than the past.

Realistic expectations regarding the greenhouse gas and energy security benefits of biofuels are also needed. Historically, crude oil and natural gas have been wonderful energy resources. Not only have they been geologically concentrated into high energy density feedstocks, their "raw form" is chemically very close to the refined products used today. This is not true for renewable resources, whether they will be converted into ethanol, biodiesel or hydrogen.

Therefore the spatial, temporal, and life-cycle dynamics of renewables need to be well known, if we are to implement the transition to a renewables dominated energy future in a robust and responsible manner.

Michael Bevan

Head of the Cell and Developmental Biology Department
at the John Innes Centre, Norwich, UK

He grew up in New Zealand, obtained an MSc in biochemistry from Auckland University in 1975, and a PhD in biochemistry from Cambridge University, UK, in 1979. At Cambridge he attended early lectures on DNA sequencing and was introduced to the nematode Caenorhabditis elegans as a model for studying molecular genetics. From 1980 to 1983 he was a post-doc at Washington University, St Louis, working on the genetics of Agrobacterium tumefaciens and crown gall tumour, with a group solving the problem of how genes originating from a bacterial plasmid can be expressed in a plant. This work led to understanding of chimaeric gene expression and the development of efficient binary transformation vectors for genetic transformation in plants. At Monsanto in the1980s Dr Bevan further developed transgene methods for crop improvement, laying the foundations for modern genetic modification (GM) technology.
Dr Bevan then returned to the UK and was soon at the John Innes Centre where he led the project to sequence the genome of the model plant Arabidopsis, completed in 2000, and contributed with European colleagues to establishing functional genomics resources. For this work he shared the Kumho award in 2001.
His research interests span genetic analysis of growth control and sugar signalling in Arabidopsis, development genomics resources for the new model grass Brachypodium distachyon, and the mapping of the wheat genome. As vice-chair of the European Plant Science Organisation, he has been involved in promoting plant research in Europe. Dr Bevan is confident that expanding knowledge of plants can soon lead to the development of bioenergy crops as sustainable and cost-effective sources of fuel and other products.

Abstract

Plant biomass for biofuel production.

My lecture describes the important role plants and plant science can play in providing sustainable bio-based energy supplies. Sunlight is our primary global source of energy and as such it provides the best opportunity for devising new technologies and strategies for generating our future energy needs.

Photosynthesis- the capture of the sun's light energy and carbon dioxide (CO2) by plants and their conversion to sugars- is a process carried out by plants, bacterial and algae. Over geological time photosynthesis established an oxygen- rich atmosphere and the remains of photosynthetic organisms were converted to coal and oil deposits. Plants and algae are the foundations of food chains that currently support nearly all life on Earth, including our own. Therefore photosynthesis is a key process that has created and currently maintains conditions for life and human activities. The rapid use of fossil fuel reserves and increasing pace of global industrialisation have progressively disturbed the balance of atmospheric gases established and maintained by photosynthesis. These changes are predicted to destabilise climates, leading to reduced food security and increased social dislocation. These factors will be further increased by increased global industrialisation and population pressures. These key global challenges must be addressed by concerted political and scientific action. Plants, having substantially contributed to establishing and maintaining a habitable and reasonably stable world, can also provide important solutions in the future.

>>

Abstract

The main part of my presentation describes the steps we are taking to develop crop plants for biofuel production. There are several major linked challenges that we have to address- how to increase the yield of plants, how to accomplish this with a reduced environmental footprint, how to alter the composition of plant material to make its conversion to biofuels economically efficient, and how to tailor the next generation of fuels for cars and aeroplanes. A major part of our current activities also involves raising the awareness of politicians and opinion makers to the potential of plant research for contributing to energy sustainability and security.

Plant research is driven by the same technological and conceptual advances that make modern biology an exceptionally fast-moving and creative environment, and it is these advances that I think will be instrumental in achieving the rapid changes needed to address these global challenges.

These technologies include the application of genomics and genetic manipulation, the discovery of new sources of biodiversity for breeding programmes, and high throughput functional genomics to identify new genes for biomass production and conversion.

This research will be conducted in a framework that gathers quantitative data from all of the research activities and uses modelling methods to identify leads and predict the outcomes of research and breeding activities. In this way the plant science community believes it can make important contributions to the "20-20" political objective of achieving 20% of transport fuel from renewal resources by 2020.

Carlo Rubbia
Nobel Laureate in Physics

Carlo Rubbia was born in Gorizia, Italy, on 31st March 1934. He graduated at Scuola Normale in Pisa, where he completed his University education with a thesis on Cosmic Ray Experiments. He has been working at CERN since 1961. In 1976, he suggested adapting CERN's Super Proton Synchrotron (SPS) to collide protons and antiprotons in the same ring and the world's first antiproton factory was built. The collider started running in 1981 and, in early 1983, an international team of more than 100 physicists headed by Rubbia and known as the UA1 Collaboration, detected the intermediate vector bosons. In 1984 he was awarded the Nobel Prize for Physics.

Carlo Rubbia has served as Director-General of CERN from 1 January 1989 till December 1993. From 1970 to December 1988 Rubbia has spent one semester per year at Harvard University in Cambridge, Massachusetts, where he was Higgins Professor of Physics.
Since 1999 to 2005 he has been the President of ENEA (Ente Nazionale per le Nuove Tecnologie, l'Energia e l'Ambiente). Carlo Rubbia is Full Professor of Physics at Pavia University, in Italy.
In 2007 he is appointed advisor for renewable energy of Italian Minister of Environment.

Zhores Alferov

Nobel Laureate in Physics. Scientific director of the Centre for the Physics
of Nanoheterostructures at the Ioffe Institute, Russia

Zhores Ivanovich Alferov was born in Vitebsk, Byelorussia, in 1930. He attended high school in Minsk, and in 1952 graduated from the Department of Electronics of the Lenin Electrotechnical Institute in Leningrad (now St Petersburg). He then joined the prestigious Ioffe Physico-Technical Institute (St Petersburg), where he obtained his doctorate in physics and mathematics (1970) and has held various positions, including director and scientific director. Professor Alferov is currently scientific director of the Centre for the Physics of Nanoheterostructures at the Ioffe Institute. Professor Alferov first became interested in the physics and technology of III-V semiconductor heterostructures in 1962. He went on to make outstanding contributions in these areas, leading to the creation of the modern heterostructure physics and electronics that made possible the development of modern lasers, solar cells, light-emitting diodes, high-speed transistors and photodetectors ? in short the realisation of the Information age. In 2000 he received the Nobel prize in physics, together with Herbert Kroemer, "for developing semiconductor heterostructures used in high-speed- and opto-electronics." Unsurprisingly he has earned many other awards for his work. Noteworthy are his early (1972) award of the Lenin Prize, the highest scientific honour in the USSR; the Golden Plate Award from the Academy of Achievement in the USA (2002); the Golden Medal of the International Society for Optical Engineering (2002); and the Global Energy Prize of the Russian Federation (2005).

In 1989 he was elected chairman of the Leningrad Science Centre of the Academy of Sciences of the USSR. In 1990 he was elected vice-president of the Academy of Sciences of the USSR (now Russian Academy of Sciences). He is editor-in-chief of the journal Technical Physics Letters. His passion for science led him to become a member of the Russian State Duma, and since 1995 has been a member of the Committee of Science and Education of that body. He works tirelessly for the promotion of science, emphasizes the importance of fundamental science for progress, and maintains that science is the main engine driving the advancement of civilization. He believes in particular that one of the most promising solutions to the problems of energy supply, atmospheric pollution and global warming is to use photovoltaic solar energy conversion devices. These are of course based on the semiconductor heterostructures for which he is largely responsible.

Abstract

Is solar energy conversion an option to solve the energy problems in future?

The relentless growth of energy consumption has led to problems of energy supply, ecological degradation, and global climate change. One of the most promising solutions to these problems is solar energy conversion.

The development and maturation of photovoltaic solar energy conversion devices, based on semiconductor heterostructures, now promises to be a technologically and even economically effective solution of the global energy problem. Recent success in creating multi-junction solar cells for concentrator arrays with an efficiency of up to 40% has drastically improved prospects in this area.

In my talk I will review the state-of-the-art of the most effective photovoltaic methods for producing solar electricity, and compare them with the prospects of development of nuclear energy and thermonuclear power.

Louis Schlapbach

Chief executive officer of Empa

and full professor of physics at the Swiss Federal Institute of Technology (ETH) Zurich

He graduated from ETH Zurich in experimental physics and obtained his PhD in solid state physics – magnetism from the same Institute. As postdoc at a CNRS laboratory in Paris, he studied hydrogen storage in intermetallic compounds. Back at ETHZ, he developed surface science aspects of the interaction of hydrogen with metals and alloys. From 1988 to 2001, he was full professor in experimental physics at Fribourg University where he recruited and headed a large research team working in the area New Materials and their Surfaces, publishing 200 scientific papers, some patents, and producing about 40 PhDs. Strong collaboration with industry was established.

Since 2001, Professor Schlapbach has been CEO of Empa - Materials Science and Technology, an institute in the ETH domain employing 750 scientists, engineers and technicians in Duebendorf-Zurich, St. Gallen and Thun.

His research interests mainly concern the nanoscopic properties of new materials and surfaces; materials for energy technologies; interaction of hydrogen with solids; and functional surfaces and coatings. His Nature paper Hydrogen-storage materials for mobile applications (414, p. 353, 2001) has been cited around 600 times; however his Springer books Hydrogen in Intermetallic Compounds I and II, are out of print.

Louis Schlapbach was member of the Swiss National Science Foundation (1997-2004) and is a member of the Committee for Technology and Innovation of the Federal Energy Research Committee (CORE), and of the Swiss Academy for Technical Sciences. He works regularly for the scientific board of the Hasler Foundation, the Fonds National de la Recherche, Luxembourg, and the Robert Mathys Foundation.

Abstract

New materials for energy technologies.

Energy is a product of nature, made available by enabling technologies, neither by politics nor by war. Sustainable use of energy is first of all efficient use.

Which forms of energy do we want or do we need to use for our biological and technical life? Food, heat, light, electricity, fuels, mechanical and gravitational energy, magnetic energy, and maybe nuclear energy. They allow us - but not all of us - to live a comfortable life with nutrition, housing, mobility, communication in an industrialized society. Most industrialized societies consume more than one third of their total energy consumption for mobility, more than one third for building technologies (heating, air conditioning, lights...) and less than one third for industry.

At comparable quality of life and degree of industrialization the consumption per capita, however, differs strongly: from 4 to 6 kW in Western Europe and Asia, up to 10 kW in USA.

Many technologies are known and some are available on the market to reduce the energy consumption very considerably: zero-non-renewable-energy buildings, safe-comfortable automobiles which consume less than 5 l gas/100 km and thus emit less than 12 kg CO2/100 km. Why do we prefer to buy comparably low efficient technologies? Energy in many forms is too cheap in industrialized countries, our energy-environment-third world ethical behaviour is not very developed, and the acceptance/non acceptance of energy technologies is to a large extent a social science rather than a technical issue.

Nevertheless (I am a physicist) I plan to focus on the progress of the following techniques: Thermoelectricity: The upgrading of low temperature heat into electricity using thermoelectric solid state devices is a dream of classical electron theory. New materials and nanostructuring offer new hope for better efficiency. Reduced Friction: Friction between tyre and road is a must; friction in mechanical machines and engines is mostly a loss of kinetic energy and its transformation into non useful heat. New coatings with quasicrystalline or complex metallic alloys allow reducing friction losses by a factor of two or more and enhancing the cyclic life time. The world wide energy saving potential exceeds 100 medium sized power stations. Fuels from Biomass: Which biomass should be transformed sustainable into biogene (hydrocarbon) fuels; which biomass should remain alimentation?

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Abstract

Hydrogen and its storage: Hydrogen as a clean carbon-free synthetic fuel is an attractive option for urban energy supply. R&D on storage materials for mobile applications progresses slowly. The approach to ask for 6 to 10 w% hydrogen storage density to run classical high mass vehicles should be questioned; it is more attractive, more sustainable and feasible to reduce the automobile weight. For ground transport of goods fossil fuels will remain the main energy option where railways are not the solution.

Zero-non-renewable-energy Buildings: Elaborated building technology combined with good design and functionally coated glass reduces the energy consumption to a very low level; zero use of fossil fuels for heating/air conditioning of new buildings needs to become a standard.

Magnetic Energy: The energy density of technical magnetic fields remains low. Nevertheless prototypes of cyclic magnetic cooling devices exist and new non- erasable magnetic data storage materials will improve safe information techniques.

Finally, as a vision, the basic ideas of the 2000 Watt Society projects of Switzerland will be presented.

Jefferson W. Tester

Meissner Professor of Chemical Engineering at MIT

He obtained his BS and MS in chemical engineering from Cornell and his PhD from MIT. For three decades he has been involved in chemical engineering process research as it relates to energy extraction and conversion, with particular interest in processes in hydrothermal and supercritical media. Other areas of interest have been biomass reforming, fossil fuel upgrading, chemical synthesis in biphasic water-carbon dioxide mixtures, and destruction of toxic compounds by oxidation in supercritical water. He also works on technologies associated with advanced drilling, geothermal energy recovery, methane reforming, and gas hydrates. Current research includes studies on hydrothermal liquefaction and gasification of feedstocks such as forest product wastes and sludges, and food processing waste.
Past positions include director of MIT's Energy Laboratory, director of MIT's School of Chemical Engineering Practice and leader of the Resource Engineering Group at Los Alamos National Laboratory.
He is a member of the American Institute of Chemical Engineers, American Chemical Society, Society of Petroleum Engineers, Tau Beta Pi, Sigma Xi, and the Geothermal Resources Council. He has been advisor to the US DOE, Defense Science Board, and National Research Council. He is a member of several scientific advisory boards including the National Renewable Energy Laboratory, the Massachusetts Renewable Energy Trust, and the American Council on Renewable Energy, and has served on the editorial boards of Journal of Supercritical Fluids, Energy and Fuels and Annual Reviews of Energy and the Environment.
Professor Tester has recently revised a core thermodynamics textbook (co-author M. Modell) and has recently published (as co-author) Sustainable Energy - Choosing Among Options.

Abstract

The future of geothermal energy as a sustainable pathway.

Recent international focus on the value of increasing our supply of indigenous, renewable energy underscores the need for re-evaluating all alternatives, particularly those that are large and well-distributed. To transition from our current hydrocarbon-based energy system, we will need to expand and diversify the portfolio of options we currently have. One such option that is often ignored or undervalued in assessments is geothermal energy from both conventional hydrothermal and enhanced or engineering geothermal systems (EGS).

A comprehensive assessment of enhanced or engineered geothermal systems (EGS) was carried out by an MIT-led, 18-member panel assembled to evaluate the potential of geothermal to become a major primary energy supply for the US. Although geothermal energy is used for both electric and non-electric applications worldwide from conventional hydrothermal resources, this study focused on the potential for EGS to provide 100,000 MWe of base-load electric generating capacity in the US by 2050. The presentation will discuss the three areas important to EGS deployment on a large scale, namely:

1 Resource - estimating the magnitude and distribution of the US EGS resource.
2 Technology - establishing requirements for extracting and utilizing energy from EGS reservoirs including drilling, reservoir design and stimulation, and thermal energy conversion to electricity.
3 Economics - projecting costs for EGS supplied electricity as a function of invested R&D and deployment in evolving energy markets.

Jeffrey Byron

Member of the California Energy Commission

Jeffrey D Byron of Los Altos, is member of the California Energy Commission, being appointed to that position by Governor Schwarzenegger in 2006.

The five members of the Commission are appointed to staggered five-year terms and require Senate confirmation. Four of the five members are required to have professional training in specific areas - engineering or physics, environmental protection, economics, and law. One commissioner represents the public-at-large, and Byron, with over 30 years' experience in the electric power industry and over 10 years of service help customers to meet their energy needs, fills the public-at-large position.

Byron also serves as Presiding Member of the Energy Commission's Electricity Committee, as Associate Member of the Siting Committee, the Transportation Committee, the Natural Gas Committee, and the ad hoc committee for the joint greenhouse gas reduction.

Prior to his appointment, Commissioner Byron was president of the Byron Consulting Group – developing strategic energy solutions for medium to large-sized firms from 2002. He also served as co-chair of the Silicon Valley Leadership Council's Energy Committee and managed an energy efficiency program to reduce energy use and carbon emissions among businesses and other organizations on behalf of the Silicon Valley Leadership Group and Sustainable Silicon Valley. From 2000 to 2001, he developed combined heat and power projects for Calpine C*Power, and was Energy Director for Oracle Corporation from 1996 to 2000. From 1985 to 1995 he served at the Electric Power Research Institute in a variety of capacities, including commercialization director and executive technical advisor.

Commissioner Byron received a BS in civil engineering and a MS in structural engineering from Stanford University.

Abstract

The many faces of energy efficiency.

California has demonstrated the practice of efficient use of energy as the primary means of offsetting a growing demand for energy. While the per capita use of electricity in the US has increased 50 percent during the past 30 years, California's use has remained relatively constant. This has happened concurrently with significant economic growth and technological advances, yet the full potential of energy efficiency has yet to be realized. Although California has been extremely successful in energy efficiency in the electricity arena, little progress has been made in the last twenty years in the transportation sector, where the federal government establishes the fuel efficiency standards.

For California to meet the greenhouse gas reduction goals set into law in AB 32, even more progress will need to be made in efficiency in all energy sectors as well as in increasing the use of low carbon energy sources. Additional savings can be achieved from a combination of structural changes, fuel efficiency improvements for the transportation sector, and improved building standards and industry practices. Given California's relatively low carbon electricity mix, increased electrification will also continue to play a significant role in improving the quality of life as well as reducing pollution. Increasing the efficient use of electric energy will continue to be an important focus as we move away from fossil fuels in a carbon constrained world.

Energy: environment & health.

The burning of fossil fuels really got underway with the industrial revolution, and has continued at an increasing pace to the present day. Carbon dioxide, released into the atmosphere by burning, is a major greenhouse gas, and according to some studies, appears to be provoking climate change on a massive scale. There will be changes in the atmosphere, the oceans and terrestrial ecosystems that will profoundly affect the lives and health of ordinary people, the world economy, and the well-being of the planet.
These far-reaching effects of past and future energy use will be discussed: the projected climate changes and their consequences will be examined, including their effects on biodiversity, individuals and humanity as a whole.

h. 9.00 a.m. - 1.00 p.m.

Chairs: **Olivier Barbaroux** and **Chicco Testa**

Richard Lindzen
Global warming: testing versus promoting

Ahmed Ghoniem
Energy resources and technologies; and approaches for low-impact utilization

Victor Smetacek
The health of planet ocean in the Anthropocene

Dianna Bowles
Working with plants to build a sustainable future

Panel discussion

h. 2.00 p.m. - 5.00 p.m.

Chairs: **Chris Bowler** and **Nicolò Dubini**

James Lovelock
Sustainable retreat

Gennaro De Michele
From steam generator to smart grid. Vision and frontiers of electricity generation

Richard Klausner
Cimate change and health - projecting and dealing with a threat already here

Panel discussion

h. 5.00 p.m. - 6.00 p.m.

AIRC Conversation: **Richard Klausner** and **Pier Giuseppe Pelicci**
Introduced by **Umberto Veronesi**
Energy sources and cancer

Richard Lindzen

Alfred P Sloan Professor of Meteorology at MIT

He trained as a physicist and applied mathematician. His PhD thesis (Harvard 1964) on interactions of ozone chemistry, radiative transfer, and middle atmosphere dynamics brought him into the atmospheric sciences where he continues to work. After periods at the Universities of Washington (1964-65), Oslo (1965-66), National Center for Atmospheric Research (1966-68), and Chicago University (1968-1972), he moved to the Burden Chair of dynamic meteorology at Harvard, also directing the Center for Earth and Planetary Physics. He moved to MIT in 1983.

Lindzen is interested in the dynamics of climate and atmospheric circulation, the middle atmosphere, and planetary atmospheres. He has contributed to the theory of hydrodynamic instabilities and waves, and provided explanations for atmospheric tides, oscillation of the tropical stratosphere, super-rotation of the atmosphere of Venus, and generation of upper atmospheric turbulence by breaking internal gravity waves. His current research is on the sensitivity of the Earth's climate to radiative forcing, factors determining equator-to-pole temperature differences, and the nature and role of atmospheric convection.

He is fellow or member of several major scientific societies including the National Academy of Sciences. He holds the Macelwane medal of the American Geophysical Union, and the Meisinger and Charney Awards of the American Meteorological Society.

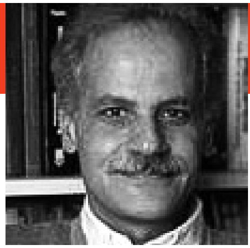
He has held visiting appointments at numerous universities throughout the world. He is coauthor of Atmospheric Tides, author of Dynamics in Atmospheric Physics, coeditor of The Atmosphere - A Challenge: The Scientific Work of Jule Gregory Charney, and has contributed to over 200 scientific papers. He was lead author of the IPCC Third Assessment Report, and has served on numerous panels of the National Research Council, Council of the American Meteorological Society and Corporation of the Woods Hole Oceanographic Institution. In 2006, he received the Leo Prize of the Walin Foundation in Sweden.

Abstract

Global warming: testing versus promoting.

The issue of global warming is typically subject to support that is based on simulation with numerous adjustable parameters. The question asked is essentially whether there is any way that models can be made to both project significant warming in the future while replicating at least the global mean surface temperature history of the past century or so. This procedure deviates importantly from conventional scientific approach which emphasizes testing hypotheses. The current approach seems designed not to test anything but rather to promote a particular type of scenario. According to the latest IPCC Scientific Assessment, one attributes recent warming to man's activities because models do not otherwise display such warming. This is almost identical to the argumentation used to support Intelligent Design. Moreover, the IPCC never states whether its iconic claim provides any support for the numerous alarming claims for the future. It also does not account for the interesting cessation of global warming during the last ten years or so.

The question addressed in the present paper is whether we can do better than this. There are, in fact, several reasonable approaches that have been taken which lead to the conclusion that the IPCC has exaggerated the role of anthropogenic greenhouse gases. We address the simplest of the possible approaches here. It is shown that the use of basic greenhouse theory coupled with carefully designed model runs (using models employed in the IPCC assessment) and readily available standard observations leads to a concrete answer to the question of how much of recent warming is due to added greenhouse gases. The results are, in some ways, not so different from what the IPCC claimed. We find that no more than a third of the observed surface warming can be attributed to greenhouse forcing as opposed to the IPCC claim that most of the surface warming is due to man. However, the approach described, by isolating the greenhouse contribution, also permits one to estimate climate sensitivity, and suggests that the impact of greenhouse additions over the next century is unlikely to significantly impact climate.



Ahmed Ghoniem

Ronald C. Crane Professor of Mechanical Engineering, at the School of Engineering, MIT

He is also co-director of the Laboratory for 21st Century Energy, director of the Reacting Gas Dynamics Laboratory, and Head of Energy Science and Engineering at MIT.

He received his BSc and MSc from Cairo University, and his PhD from the University of California, Berkeley. His research has led to major advances in high performance computing and computational methods for the simulation of reactive flow. He has also made innovations in active control, and the application of active control to combustion including the formulation of reduced-order models, model-based control and microactuation for the suppression of dynamics and emissions in propulsion systems. Ghoniem has also been intimately connected with the development of new techniques in energy systems analysis, focusing on efficient solid oxide fuel cells and low-carbon conversion through gasification of high-carbon feedstock and biomass, and utilization of oxy-combustion processes.

His recent interests encompass hybrid and integrated energy and propulsion systems, alternative fuel and alterative engines, integration of renewable and fossil fuel-based energy, and carbon management. He has published over 160 articles in leading journals, and lectured extensively in the fields of simulations and computations, combustion and control, and energy systems analysis.

Ahmed F. Ghoniem has been consultant for several major aerospace, automotive and energy companies, and for leading government research laboratories; he has also served on the boards of high-performance computing centers and laboratories. He has won teaching and scholarly awards, is associate fellow of American Institute of Aeronautics and Astronautics, and Fellow of American Society of Mechanical Engineers.

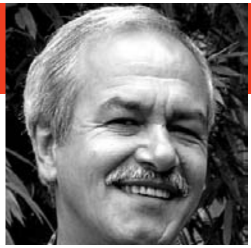
Abstract

Energy resources and technologies; and approaches for low-impact utilization.

Energy "powers" our life, and energy consumption correlates well with our standard of living. The developed world has become accustomed to cheap and plentiful supplies of energy; more and more in the developing world are striving for the same fortune. Competition over limited supplies of conventional resources is intensifying, and more challenging environmental problems are springing up, especially related to carbon dioxide emissions. Atmospheric concentration of carbon dioxide and the average global temperature rise are strongly correlated, and predictions indicate that the observed trends over the past century will continue. Given the potential danger of such a scenario, steps must be taken to curb energy related carbon dioxide emissions through a number of strategies, enabled technologically and applied in a timely fashion.

These strategies include a substantial improvement in energy conversion and utilization efficiencies, carbon capture and sequestration, and expanding the use of nuclear energy and renewable sources. Opportunities exit in all three approaches. Conversion efficiency gains through integration and hybridization, electrochemical processes and thermoelectric conversion of waste heat will simultaneously extend the lifetime of resources and cut emissions. Extensive deployment of onshore and in particular offshore wind energy is timely because of the favorable economics.

Solar thermo-electric conversion is a proven and scalable technology, with the added advantage of large-scale storage potential. Studies show that carbon capture and storage from power plants that use heavy carbon resources is feasible but further development of capture technology and demonstration of the success of long term storage are needed. Similar processes must be used in synfuel production from the plentiful resources of heavy hydrocarbon. The requisite technologies for some of these solutions already exist, but will have to be deployed at substantially larger scales to make the desired impact. Other technologies are under development, and some are still at the conceptual state. A portfolio of solutions must be pursued. The World must undertake steps to achieve a global energy policy that mitigates the negative impact of the rising consumption, and achieves a fair and balanced distribution of the resources and the burden.



Victor Shahed Smetacek

Professor of bio-oceanography at the University of Bremen,
and also heads the Departments of Pelagic Ecosystems, and Biological Oceanography,
at the Alfred Wegener Polar and Marine Research Institute, Bremerhaven, Germany

Professor Smetacek acquired his BSc in 1964 from a college in India, where he grew up, and then studied marine biology at Kiel University. His was involved in a multidisciplinary project on interactions between the water column and the sea bed, making the important discovery that diatom blooms are not consumed by zooplankton but tend to settle out on the sea floor.
When he joined the Alfred Wegener Institute in 1986, his research shifted to the Southern Ocean and the biology of sea ice and ice-covered waters. He coordinated the successful European Polarstern Study (EPOS) of the European Science Foundation from 1987 to 1992 and subsequently coordinated an interdisciplinary research group to probe the role of the Antarctic Circumpolar Current in global carbon and silicon cycles. He was chief scientist on five cruises of the 17,000 ton polar icebreaker Polarstern. Two cruises performed successful in situ iron fertilization experiments, and discovered the significant sinking out of iron fertilization-induced diatom blooms ? a finding suggesting that iron fertilization might be a feasible technique for the large-scale sequestration of atmospheric carbon dioxide.

In addition to his publications in the area of pelagic ecosystems, and links between ecology and biogeochemistry, he has published his ideas on the relationship between the human body and mind, and on how people make sense of the world around them. He has been appointed adjunct scientist by the National Institute of Oceanography in Goa, India, and is involved in preparing an iron fertilisation experiment to be carried out by India in 2009.

Abstract

The health of planet ocean in the anthropocene.

The long-term cooling trend of glacial/interglacial climate cycles, during which humankind evolved, is now reversing and we are rapidly entering a new state that is as distant from the Holocene as the Holocene was from the Pleistocene (last ice age). Paul Crutzen has appropriately dubbed this new era the Anthropocene, which however began long before the current industrial onslaught. By exterminating the megafauna of elephants and other large grazers, human hunters inadvertently changed the landscapes of all northern continents from grassland or mammoth steppe to forest. The propensity of human to exterminate megafauna and introduce its own domestic animals is now manifesting in the sea: the whales have not yet been saved and some fish populations will take centuries to return to former numbers, if ever allowed to do so. In the meantime, aquaculture techniques, analogous to those that produced the agricultural and animal husbandry revolution on land, are developing fast. Who can stem the demand for healthy, tasty sea food as people become wealthier?

The realisation that the oceans are changing rapidly is slowly dawning on the marine scientific community, but we have not woken up to the consequences of those changes. Not only the sea surface, also the deep sea is warming, and profound changes in ocean circulation are being anticipated by increasingly sophisticated models. The feedback processes have positive signs, meaning that rates of change will accelerate. The melting of the Greenland ice cap, which will devastate coastal ecosystems throughout the world, and result in massive displacement of human populations, is not a risk but a certainty.

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Abstract

The processes leading to it are ongoing, and will continue, even if atmospheric CO2 concentrations are frozen at their current levels ? which of course will not happen. Clearly we must do something and soon. But what? And how do we go about it? Cutting CO2 emissions is so obvious that I will not discuss it here.
It is now accepted that iron supply regulates productivity of the open ocean and that iron in dust from the continents settling on the ocean can have an impact of atmospheric CO2 levels. The feedback is a negative one: the more iron, the more CO2 gets taken up, the cooler it gets, the drier it gets, the more dust blown off the continents by the winds and so on. We have shown, in open-ocean mesoscale experiments, that artificial iron fertilisation of the Southern Ocean results in build-up of phytoplankton biomass which then sinks out to deep layers, taking the carbon with it. Thus CO2 is sequestered from the atmosphere.
This can occur over the scale of centuries and in amounts equivalent to 25% (depending on fertilisation intensity) of annual atmospheric accumulation rates (3.4 Gigatonnes).
This amount is particularly significant in view of the relatively minor effort in terms of costs and CO2 emissions required. Clearly, large-scale fertilisation is an important option for mitigating the worst effects of global warming, and we can no longer afford to ignore this option.
Large-scale, long-term, multi-ship experiments must now be carried out to explore the best locations and seasons for this undertaking. Rather than merely bemoaning possible negative effects of iron-fertilization, the scientific community should also examine possible beneficial effects such as the build-up of krill biomass and, possibly, a build up of whale populations.
In effect, we will be cultivating a glacial ocean and hope that it will have a mitigating effect on global warming. It is up to us to restore the health of the ocean. But what would this imply?

Dianna Bowles

Professor of biochemistry at the University of York, UK,
and founder and head of the Centre for Novel Agricultural Products (CNAP)

She trained in plant sciences, and gained a PhD in biochemistry from Cambridge. After post-doc positions in Europe, she came to Leeds University in 1979, gaining a personal chair in plant biochemistry in 1990, and later directing the Centre for Plant Biochemistry & Biotechnology. She moved to the University of York in 1994, and in 2001 founded CNAP. Professor Bowles believes that while plants are already major sources of medicines, materials, food and energy, they have the potential to provide much more, by the development of integrated biorefineries to convert plant feedstocks into many different products including energy.

A basic concern of her research is how plants respond to stresses. She is interested in the large multigene family of glycosyltransferase (GT) enzymes involved in plant stress management. GTs transfer monosaccharides to acceptor molecules and in doing so modulate levels and activities of hormones, detoxify pesticides and herbicides, and regulate secondary metabolism. Her group found that GLs can transfer sugar groups to natural products, and are hence useful for stereo- and regio-selective biotransformations: recombinant GTs are being used to discover and design new regio- and stereo-selective biocatalysts for fermenter-based biotransformations. CNAP is also seeking to obtain sustainable supplies of the potent anti-malarial drug artemisinin from high-yield varieties of the plant Artemesia.

Professor Bowles founded and was Editor-in-Chief of The Plant Journal for 11 years, and has served on many UK government committees. She co-founded the National Non-Food Crops Centre, is a member of the US-EU Taskforce in Biotechnology Research Steering Group on Plant Bioproducts, and directs EPOBIO, an EU-funded consortium to realise sustainable non-food uses of crops.

Abstract

Working with plants to build a sustainable future.

Today's society is living on ancient sunlight - the energy and carbon captured millions of years ago and comprising our fossil reserves. Globally, we are now recognising we must live on the sunlight of today and tomorrow - using the plants in our agriculture, forestry and seas to provide feedstocks for industry and fuel as well as food.

Understanding plants provides the route to their most effective and sustainable use. This knowledge underpins quality and yield of the different raw materials, how best to gain energy from biomass, domestication of new plant species for industrial uses, and how to reduce fertilizer, pesticide and water inputs to develop more sustainable cropping systems.

These issues are relevant to land-use decisions in both the developed and developing world and can provide an informed evidence-base to increase the industrial uses of plants whilst protecting the global environment and the security and quality of the food chain.

Future water availability will be a key determining factor in the choice and development of crops for both food and non-food applications. And again, this issue is of relevance to future agricultural systems in both the developing and developed nations.

This presentation will explore a process for analysing science-based solutions for the use of plants, within a wider context of environmental impacts, socio-economics, regulations and the attitudes of the public and policy makers. Case studies will be presented, in which alternative solutions for energy and non-energy products have been considered in this holistic framework. These cost-benefit analyses have been used both to define new targets for sustainability and to provide recommendations for policy decisions to achieve those targets.

Within the strategic policy process there is an urgent need to develop sustainability criteria against which new developments for the use of plants can be assessed.

The power of plants is immense – whether within the terrestrial or aquatic environments. Already, plants provide sources of energy for communities worldwide, as well as medicines, materials and food. Working with plants offers a clean technology, developing high capacity production systems of different chemicals for multiple uses.

The full potential of these complex raw materials will only become realized through the design of integrated biorefineries that are capable of converting the plant feedstocks into many different products. Energy will be one product, but as the bio-economy develops, new applications and additional products will ensure the full value of the plant production system is recognized and used.

James Ephraim Lovelock

Honorary Visiting Fellow of Green College, University of Oxford.
Originator of the Gaia Hypothesis

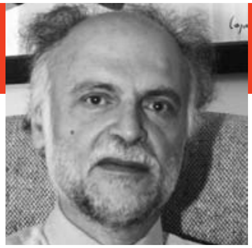
James Ephraim Lovelock was born on 26 July 1919 in Letchworth Garden City in the United Kingdom. He graduated as a chemist from Manchester University in 1941 and in 1948 received a Ph.D. degree in medicine from the London School of Hygiene and Tropical Medicine. In 1959 he received the D.Sc. degree in biophysics from London University. After graduating from Manchester he started employment with the Medical Research Council at the National Institute for Medical Research in London.

In l954 he was awarded the Rockefeller Travelling Fellowship in Medicine and chose to spend it at Harvard University Medical School in Boston. In 1958 he visited Yale University for a similar period. He resigned from the National Institute in London in 1961 to take up full time employment as Professor of Chemistry at Baylor University College of Medicine in Houston, Texas, where he remained until 1964. During his stay in Texas he collaborated with colleagues at the Jet Propulsion Laboratory, Pasadena, California on Lunar and Planetary Research.

Since 1964 he has conducted an independent practice in science, although continuing honorary academic associations as a visiting professor, first at the University of Houston and then at the University of Reading in the U.K. Since 1982 he has been associated with the Marine Biological Association at Plymouth, first as a council member, and from 1986 to 1990 as its president.

James Lovelock is the author of more than 200 scientific papers, distributed almost equally among topics in Medicine, Biology, Instrument and Atmospheric Science and Geophysiology. He has applied for more than 40 patents, mostly for detectors for use in chemical analysis.

He is the originator of the Gaia Hypothesis (now Gaia Theory) and has written three books on the subject: Gaia: a new look at life on Earth (Oxford University Press, 1979); The Ages of Gaia (WW Norton, 1988); Gaia: the practical science of planetary medicine (Gaia Books, 1991); and an autobiography, Homage to Gaia (Oxford University Press, 2000). His latest book is The Revenge of Gaia (Allen Lane/Penguin 2006).



Gennaro De Michele

Executive Vice President of Enel Research

Gennaro De Michele is executive vice president of Enel Research, the research arm of the Italian Power Utility. He is also a member of the Advisory Council of the European Commission's Technology Platform for Zero Emission Fossil Fuel Power Plants; member of the International Energy Agency's Clean Coal Science Group; and general secretary of the International Flame Research Foundation.
He is author of over 200 publications and holds 15 patents. He has received several awards including the Philip Morris Prize for Scientific and Technologic Research; the Industry and Environment Prize of the Italian Minister for Industry; and the Environment-Friendly Innovation Award of Legambiente (the Italian environmental group) and Bocconi University. Gennaro De Michele was born in Naples in 1950 and graduated with honours in Chemical Engineering from the University of Naples.

Abstract

From steam generators to the smart grid.
Future and frontiers of electricity generation.

Over the last 50 years, the working vision of electricity producers has changed profoundly. In the 1960s, power plants were considered pressure cookers, and the environment a bottomless pit capable of absorbing and digesting all types of pollutants. Attention was then focused on steam generators and turbines and steam conditions increased significantly to well over critical values. The key word at that time was efficiency and remarkable improvements in efficiency were achieved, resulting in a significant increase in useful energy yields. As attention shifted towards environmental problems in the 1080s the vision changed: power stations came to be seen as chemical reactors and the environment as a biochemical reactor under threat from the emissions of power plants. The key word was chemistry, and technologies borrowed from the chemical industry enabled emissions to be reduced to previously unimaginable levels. However, although environmental technologies have helped solve many of the problems of polluting emissions, they have not been able to deal with greenhouse gas emissions, and in particular CO2. New technologies are appearing such as carbon capture and sequestration (CCS) which may be able to reduce CO2 dispersion inro the atmosphere thereby prolonging the lives of traditional power plants. One CCS technology involves the production of hydrogen, opening up the prospect that fossil fuel power stations may produce hydrogen as well as electricity. This hydrogen could be put to use to power vehicles thereby reducing pollution in clogged cities. But while CCS is being researched and developed, another newer vision is capturing people's imagination: distributed generation.
Today's electricity networks provide an essential service to society and are designed and built to ensure every customer has access to electricity. They are developed vertically: centralised power station and distributed consumers, with limited interconnections between control areas.

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Abstract

This vertical organisation is likely to change profoundly in the future for various reasons, the first being the increasing use of renewable energy sources. By their nature, renewable energy sources are distributed, discontinuous and often intermittent, and although there are exceptions (hydroelectric plants, geothermal stations and large wind farms), these forms of energy generation are on a much smaller scale.

In addition to resources, electricity produced from natural gas and biomass, and later from hydrogen, using small boilers, internal combustion engines, microturbines and fuel cells in highly efficient co-generative systems is destined to grow favoured by an increasingly open market. This new holistic vision evokes the idea of living tissue and its key word is network ? a network in which each node is not simply an electricity sink, but also a point of electricity generation. This holistic approach to energy supply can ensure that all relevant factors are considered in system operations and development, so that passive networks become active, consenting a multitude of operators to participate in managing the generation system.

The new networks will be flexible ? capable of responding to changes in the structure of the generation systems; accessible ? guaranteeing the connection of new users and new generators; reliable ? ensuring quality of service and, finally, cheap ? reducing costs and promoting competition. They will be fundamental instruments for implementing new technologies, and will have the potential to increase energy availability. However, setting up new generation systems will require exceptional effort, necessarily involving a change in the way traditional electricity production is perceived and the creation of professionals able manage this new power generation vision.

Richard Klausner

Former Director Global Health, Gates Foundation.
Independent consultant in the area of biotech and global health,
and managing director of The Column Group, a strategy-based venture fund.

He received his first degree from Yale university and a medical degree from Duke university. After post-graduate medical training at Harvard, he began research at the US National Institutes of Health in 1979. He is well known for his work in cell and molecular biology, and for some years was highly cited in biological and biomedical areas. He helped elucidate the biochemistry of various metals that are essential but toxic nutrients for most life forms; made important discoveries in the cellular trafficking of molecules; and described new gene regulation mechanisms.

His career in the policy and science administration fields ran parallel with his research career. From 1984 until 1997 was Chief of the Cell Biology and Metabolism Branch of the National Institute of Child Health & Human Development. In 1993 he was elected to the National Academy of Sciences where he led efforts to write standards for science education for the United States. In 1995 he was appointed Director of the National Cancer Institute – one of the world's largest research and health agencies – where he created successful national and international programs to apply science and technology to improving public health. In 1996, he was elected to the US Institute of Medicine.

Following the events of September 11th 2001 Dr Klausner became prominent as Special Advisor to the US Presidents for Counterterrorism. Around the same time (2002) he was named Executive Director of the Bill and Melinda Gates Foundation's Global Health Program, whose main goal is to improve global health equity; however he resigned in 2005.

Abstract

Climate change and health - projecting and dealing with a threat already here.

Despite bickering politicians, there is extraordinary unanimity among the scientific community that climate change is upon us. It will have profound effects on human health. There are many ways to think about these changes, from the modeling of climate and weather to predicting direct and indirect consequences on human health. As with climate itself, the precise patterns and magnitude of health consequences are hard to predict. But, despite this uncertainty, we can already see certain effects and reasonably predict others.

Climate effects can be the result of long-term changes in measures such as average temperatures and rainfall, acute extremes and cataclysmic events. They are all apparently connected. We know that as average climate changes, the number and extent of sudden, transient extremes increase. Furthermore, it is also predicted that the number and severity of anomalous events such as severe hurricanes and cyclones, severe thunderstorms, tornadoes and other acute severe events will rise with global warming.

We can examine the health effects of global warming in terms of:
- Direct effects.
- Indirect effects based on alterations of the nature and distribution of ecosystems that relate to human disease.
- Indirect effects based on changes to agriculture.
- Direct and indirect effect on health of severe, anomalous events.

The most obvious direct effects of warming on health are human disease/disability and death due to heat. The WHO already estimates that, as a result, of recent increases in both average temperature and of the extremes of heat waves, there are five million more episodes of disease and 150,000 more deaths per year. The major diseases altered or exacerbated are infectious diseases, cardiovascular disease and respiratory disease.

>>

Abstract

The most striking indirect disease effect due to ecosystem change are infectious diseases whose biology includes insect vector transmission as alterations in insect ecology are undergoing dramatic changes. The insect vector borne disease that currently takes the highest toll on human life is malaria and all indicators point to spread of this disease. But, malaria is far from alone in this category of infectious diseases.

Human health absolutely depends upon adequate nutrition. The effect of climate change, already apparent in the droughts of Africa are portends of things to come and illustrate the profound health consequences of agricultural failure. The horn of Africa and Sudan are early case studies in the impact of severe climate stress, which in part underlies the devastating wars which, in turn, have resulted in dramatic health crises.

Finally, acute severe weather, whether in poor countries or rich, result in profound acute and chronic health consequences from disruption of health services, disruption of clean water supplies, infectious diseases (especially diarrheal), stress and trauma.

The global climate crisis is due to manmade carbon pollution based on the many ways that we create CO2 as a result of energy production in buildings, power plants, vehicles, etc. Perhaps it is ironic that the CO2 pollution that is causing health threatening climate change also contributes dramatically to health deterioration via pollution. I will discuss the profound respiratory and cardiovascular disease burden of carbon-based energy production as one more aspect of this overall problem.

Energy: ethics, politics and economics.

The energy challenge is now known to be related in a fundamental way the global environmental challenge. Both have major ethical, political and economic implications.
For both, a key concept is sustainability, whose ramifications and implications are emerging from research involving the physical and natural scientists on one hand and the social scientists on the other.
The sustainability of development is being put under serious pressure by the burgeoning economic growth of the Asian economies and their billions of citizens. Strategies to address energy needs and environmental problems must be practical enough to form a basis for stable international agreements but cannot afford to neglect the ethical dimension, since decisions are being taken that will have major impacts on future generations.

h. 9.00 a.m. - 1.00 p.m.

Chairs: **Ignazio Musu** and **Philip Pettit**

Joachim Schellnhuber
Climate change: a grand challenge for sustainability science

Vaclav Smil
Energy transitions: expectations and realities

Carlo Carraro
Climate policy in the post-Kyoto world. Incentives, institutions and equity

Partha Dasgupta
Globalization and the natural environment

David Blackbourn
The culture and politics of energy in Germany: an historical perspective

Panel discussion

h. 2.00 p.m. - 4.00 p.m.

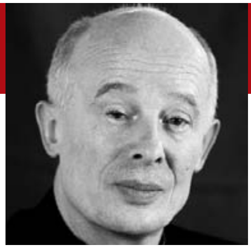
Chairs: **Kathleen Kennedy Townsend** and **Marcelo Sanchez Sorondo**

Jean Jacquinot
The case for a world collaboration on fusion and ITER

Fulvio Conti
Energy supply equation

Giuliano Amato
Closing Lecture

Final Remarks
Giovanni Bazoli, Chiara Tonelli, Marco Tronchetti Provera, Umberto Veronesi



Joachim Schellnhuber

Director of the Potsdam Institute for Climate Impact Research (PIK)
and professor of theoretical physics at Potsdam University

He trained in physics and mathematics at Regensburg University, Bavaria, and obtained a doctorate in theoretical physics in 1980. After research abroad, including at several institutions of the University of California, he became full professor at the Interdisciplinary Centre for Marine and Environmental Sciences at Oldenburg University in 1989, and was subsequently appointed its director.
In 1991 he became founding director of the PIK; and since 1993 has been PIK director and professor at Potsdam. Additional engagements in the period 2001-2005 were research director of the Tyndall Centre for Climate Change Research and professor at East Anglia University (UK). He remains distinguished science advisor to the Tyndall Centre.

Professor Schellnhuber has served on numerous national and international panels for scientific strategy and policy advice on the environment and development. He was chief German government advisor on climate and related issues during the German G8-EU twin presidency 2007; and has been member of the High-Level Expert Group on Energy and Climate Change advising JM Barroso, European Commission President.

He has published about 200 articles and 40 books in the fields of condensed matter physics, complex systems dynamics, climate change, earth system analysis, and sustainability science. His awards include Royal Society Wolfson Research Merit Award (2002) and Commander of the Order of the British Empire awarded by Queen Elizabeth (2004). He is elected member of the Max Planck Society, German Academy Leopoldina, US National Academy of Sciences, Leibniz-Sozietät, Geological Society of London, and International Research Society Sigma Xi. He is visiting professor in physics and senior James Martin Fellow at Oxford University.

Abstract

Climate change: a grand challenge for sustainability science.

It has often been observed that the term "sustainable development" is something like an oxymoron, as it evokes the perspective of an unlimited improvement of human civilization on our fairly limited planet. In fact, aiming for global sustainability means to address a number of dichotomies as reflected in seemingly antagonistic pairs of notions like preservation vs. progress, spontaneity vs. reliability, responsibility vs. competitiveness, or equity vs. optimality.

Sustainability science inherits this dichotomical character from its subject when analyzing the viability of human-environment systems and identifying strategies for qualified/conditional management that does not compromise quintessential features of those systems. As a consequence, research in this emerging field has to contrast – and reconcile – complexity with predictability, intuition with expertise, flexibility with planning, contextualization with decomposition, or participation with detachment.

In my lecture, I will try to demonstrate that anthropogenic climate change is a showcase challenge for sustainability science. To that end, I will first introduce a core set of sustainability principles and apply them to the global warming problem. Second, I will discuss in some detail four crucial dichotomies that handicap the search for appropriate response strategies: (i) social fairness vs. environmental integrity (how to ensure the well-being of some 9 billion people on Earth without destabilizing the climate system); (ii) scientific certainty vs. political precaution (how to deal with low to medium-probability high-impact effects like the activation of so-called tipping points); (iii) climate protection vs. planetary control (how to confine global warming without falling into the geoengineering trap); and (iv) place-based approaches vs. transboundary management (how to foster local energy autonomy without ignoring the options for long-distance integration of renewable sources).The talk will be wrapped up by a shortlist of research priorities.

Vaclav Smil

Distinguished professor at the Faculty
of Environment of the University of Manitoba, Canada.

He was born in Pilsen, Bohemia, in 1943, followed an interdisciplinary program at the Faculty of Natural Sciences of Carolinum University in Prague and obtained a Doctor of natural sciences degree. He obtained his PhD from the College of Earth and Mineral Sciences at Penn State University, US.
Professor Smil is distinguished primarily as a thinker about energy problems and as a prolific and clear-sighted writer on global energy issues. He has 25 books to his credit and has published more than 300 papers. His research interests are interdisciplinary, encompassing the environment, energy, food, population, and economic and public policy. He is particularly interested in the quantification and modelling of global biogeochemical cycles and long-range appraisals of energy and environmental options. Since the early 1970s he has applied these approaches to energy, food, and environmental affairs of China.

He fellow of the Royal Society of Canada, was the first non-American to receive the American Association for the Advancement of Science's Award for Public Understanding of Science and Technology, and has been an invited speaker to over 180 conferences and workshops across the world. He has given invited lectures at many universities around the world, and briefings and testimonies to the White House, US House of Representatives, Office of Technology Assessment of the US Congress, US State Department, and Canadian Department of Foreign Affairs. He has also acted as consultant to the American Academy of Arts and Sciences, Center for Futures Research, East-West Center, International Research and Development Center, Rockefeller Foundation, US Agency for International Development, US National Academy of Sciences, World Bank, and World Resources Institute.

Abstract

Energy transitions: expectations and realities.

Energy use has never remained static - both as far as the primary energies and the most common conversion techniques are concerned - for too long. But the tempo of energy transitions has differed substantially as extended periods of relative stability have been punctuated by relatively rapid shifts to new energy sources and new means of conversion. By the 1890s the use of biomass (mainly wood) fell below 50% of the total energy use in the Western world, and the affluent economies accomplished their transitions to fossil fuels by 1950. The most important subsequent shift was toward hydrocarbons and higher shares of primary electricity.

But the new consumption pattern, that was established rather rapidly by the 1970s, has become clearly unsustainable, either because resource limitations (inexpensive hydrocarbons) or because of environmental considerations (excessive emissions of carbon). Consequently, high-income economies are now in the early stages of a new energy transition, shifting toward a new pattern of use that will be eventually dominated by conversions of renewable energy flows (but we cannot exclude a major contribution by nuclear electricity). History of technical advances, economic and infrastructural imperatives and social considerations must temper all those fashionable, but unrealistic, expectations: this latest energy transition will extend across many decades, and during the first half of the 21st century the global energy use will remain dominated by fossil fuels.

This reality will be in a large part due to changes in Asia where energy use in China and India, the world's two most populous economies, was dominated by biomass fuels into the 1960s but where recent transition to fossil fuels and primary (hydro and nuclear) electricity has led to some spectacular increases in demand for coal, oil and natural gas, as well as to the construction of hydro megaprojects and plans for major nuclear expansion. I will take a closer look at the economic, strategic and environmental implications of this Asian energy transition as well as at the realistic possibilities of its greening during the coming decades.

Carlo Carraro

Professor of Environmental Economics and Econometrics, and Vice Provost for Research Management and Policy, at the University of Venice

He graduated from Ca' Foscari University, Venice, in 1981. After a period at the Institute of Mathematical Economics and Econometrics, Free University, Berlin, he went to Princeton USA, where he obtained a PhD in economics in 1985. He subsequently taught at several European universities.
Professor Carraro is an eminent economist who has written extensively on monetary and fiscal problems in open economies; monetary policy coordination in Europe; international negotiations and formation of international economic coalitions; effects of fiscal policies on oligopolistic markets; and econometric modelling of integrated economies. His current research includes coalition and network formation (formation of regional blocs), analysis of international economic agreements, links between trade and the environment, development of integrated climate-economy models, analysis of climate policy, empirical modelling of technological change, and the cost-benefit analysis of greenhouse gas stabilization policies.
Other roles include Director of Research at the Fondazione ENI Enrico Mattei; director of the Climate Impacts and Policy Division of the Euro-Mediterranean Centre on Climate Change; and Board member, European Climate Forum. He is also member of the Scientific Advisory Board of the Potsdam Institute for Climate, the Research Network on Sustainable Development (R2D2), the Coalition Theory Network, and the Environmental Economists' Network of the European Environmental Agency.
He is an author of the Third Assessment Report of the Intergovernmental Group on Climate Change; collaborates with the Economic and Social Research Institute, Cabinet Office, government of Japan; is consultant to the World Bank; co-edits the Review of Environmental Economics and Policy, and is on the editorial board of numerous academic journals. He has published 30 books and over 200 articles on economic issues.

Abstract

Climate policy in the post-Kyoto world Incentives, institutions and equity.

The Kyoto protocol is widely recognized as an insufficient but important first step to controlling climate change. It is therefore important to consider whether the policy architecture to be adopted post 2012 – in the post Kyoto world – should be based on the principles and steps contained in the Kyoto protocol, or should encompass a different approach to the control of climate change.
A number of features of the Kyoto protocol have been criticized: the objective of universal participation, the focus on binding targets, the fact that little effort was made to stimulate the development of new energy technologies, and the lack of effective measures to get developing nations involved. More generally, there was no mechanism to ensure equitable sharing of effort to reduce greenhouse gas emissions; there were no institutions to enforce adopted targets; and targets and measures were not linked to incentives (which should be carefully tailored to individual countries).

Incentives, institutions and equity are often neglected in the study of climate policy, which has mainly focused on concepts like optimality and cost effectiveness. Most economic analyses of climate policies have focused on a global target and on the best or most cost-effective way of achieving it; but have largely neglected incentives to get negotiating countries to agree to targets; have neglected policy instruments that can provide such incentives; and have paid insufficient attention to distributional issues or the institutions necessary to implement policy instruments and enforce targets.

If incentives, institutions and equity are to be adequately considered when drawing up the post Kyoto climate policy architecture, this immediately begs the question as to whether the new architecture should be based on the Kyoto framework or something else. This lecture addresses this question by analyzing several recent proposals for an international agreement on climate policy and attempts to identify the main features that such an agreement should ideally possess.

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Abstract

Abstract

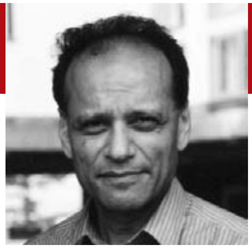
The main conclusions of the analysis are as follows. A bottom-up, country-driven approach to defining national commitments should be adopted. Instead of top-down, global negotiations on national emission targets, each country or group of countries should determine its own contribution to the cooperative effort to curb greenhouse gases, and choose the partners it wishes to work with. In a process analogous to trade negotiations, each country should put its offer of commitments on the negotiating table and invite proposals from other countries for similar commitments.

A fragmented climate regime characterized by the formation of climate blocs (regional coalitions for example) would then emerge in much the same way as emerges in trade negotiations. Some domestic or regional initiatives to reduce greenhouse gas emissions today may then pave the way to a global agreement tomorrow.

The basic ingredients of an international architecture for the climate policy would be: (i) Coordination of a variety of efforts: countries would agree on things to do rather than on emission reduction targets. (ii) Variable participation geometry: some countries would agree to do more than others. (iii) An accountability system to ensure that commitments result in action. However we must not forget that institutions able to implement an effective climate policy do not exist at the international level, although they sometimes exist at domestic and regional levels.

How can such a policy be achieved? More and better cooperation on greenhouse gas emission control could be achieved by limiting the number of negotiating countries to the most important ones (e.g. the 20 top polluters). Issue linkage and transfers (through economic cooperation) could also be important means of providing incentives to reluctant countries. Negotiations should focus on the use of different complementary policy tools (technological cooperation, climate related trade rules, carbon taxation, carbon sinks, contribution to a global adaptation fund, forestry preservation, biofuels, development aid, energy infrastructures, are some examples). A mechanism for review and scrutiny would also be necessary. Furthermore the equity issue can no longer be neglected. If countries agree on different sets of efforts, how can the costs of these efforts be assessed and compared? Can we develop a metric for effort?

The policy framework outlined implies that climate change is no longer an environmental problem to be dealt with specific environmental policy measures. It is a global economic problem to be dealt with global economic policy measures. Whatever issues world leaders meet to discuss, climate change should be a dimension of those discussions.



Sir Partha Dasgupta

Frank Ramsey Professor of Economics and past Chair of the Faculty of Economics at the Cambridge University, and Fellow of St. John's College, Cambridge

He taught at the London School of Economics (1971-1984) and moved to Cambridge in 1985. He was also Professor of Economics, Professor of Philosophy, and Director of the Program in Ethics in Society at Stanford University (1989-1992); and served as Chairman of the (Scientific Advisory) Board of the Beijer International Institute of Ecological Economics, Stockholm (1991-1997).

Dasgupta's research interests cover welfare and development economics, economics of technological change, population, environmental and resource economics, game theory, and the economics of undernutrition. Publications include Guidelines for Project Evaluation (1972), Economic Theory and Exhaustible Resources (1979); The Control of Resources (1982); An Inquiry into Well-Being and Destitution (1993); Human Well-Being and the Natural Environment (2001; revised 2004); and Economics: A Very Short Introduction (2007).

Professor Dasgupta is fellow or member of numerous learned societies including the Econometric Society, British Academy, Royal Society, Pontifical Academy of Social Sciences, Third World Academy of Sciences, American Economic Association, American Academy of Arts and Sciences, US National Academy of Sciences, and American Philosophical Society. He is past President of the Royal Economic Society, European Economic Association, and Section F (Economics) of the British Association for the Advancement of Science's Festival of Science. He was named Knight Bachelor by Queen Elizabeth II in 2002 for "services to economics," and was co-winner of the 2002 Volvo Environment Prize, and the 2004 Kenneth E. Boulding Memorial Award of the International Society for Ecological Economics.

David Blackbourn

Coolidge Professor of History, and Director of the Center for European Studies,
at Harvard University

He holds a BA and PhD from Cambridge University, where he was a research fellow at Jesus College. He taught at London University from 1976 to 1992 before moving to Harvard. He was Visiting Kratter Professor of History at Stanford University in 1989-90. He has held fellowships from the John Simon Guggenheim Memorial Foundation, the Alexander von Humboldt Foundation, the Institute for European History in Mainz, and the German Academic Exchange Service. A former president of the Conference Group for Central European History of the American Historical Association, he is vice-president of the board of directors of the Friends of the German Historical Institute, Washington, a member of the editorial board of Past and Present, and an elected Fellow of the Royal Historical Society (UK) as well as of the American Academy of Arts and Sciences.
His books include Class, Religion and Local Politics in Wilhelmine Germany (1980), The Peculiarities of German History (with Geoff Eley, 1984), Populists and Patricians (1987), Marpingen: Apparitions of the Virgin Mary in Bismarckian Germany (1993 - winner of an American Historical Association prize for best book on German history), Germany 1780-1918: The Long Nineteenth Century (1997, 2002), and The Conquest of Nature: Water, Landscape and the Making of Modern Germany (2006). David Blackbourn has given many named lectures, including the Annual Lecture of the German Historical Institute London (1998), the Malcolm Wynn Lecture (2002), the George C. Windell Memorial Lecture (2006), and the Crayenborgh Lecture (2007). His books and articles have appeared in German, French, Italian, Spanish, Portuguese, Serbo-Croatian, Japanese and Korean.

Abstract

The culture and politics of energy in germany: an historical perspective.

This is a paper by an historian, not a policy-maker or scientist. One of the most fruitful but still too little discussed recent developments within the historical discipline is the growing interest of some practitioners in scientific disciplines such as paleontology, physical anthropology, and not least, ecology and environmental science—all sciences that have historical change built into them. Historians are usually shy about addressing the future; the only thing we are good at predicting is the past. But in the case of energy, as of other key environmental issues such as water resources, the longer historical time-frame is instructive. This paper seeks to deepen our understanding of present-day choices and debates about energy in Germany by showing how these emerged, suggesting parallels in the past, and pointing out the political and cultural as well as economic contexts of successive German energy regimes over the last two centuries.
The paper starts by noting what Germany has in common with other EU members, starting with the fact that policy on energy - as on other environmental issues like river basin and flood management - is formulated within broad EU guidelines. Germany, like other EU states, also has a complex, politically contested energy mix, and is dependent on outside energy sources. These, most obviously in the case of oil and gas, raise geopolitical questions. The paper then identifies distinctive characteristics of the German situation. First, from 1949 to 1990 there were two Germanys, each integrated into a different political bloc, dependent on different markets and different sources of energy; and the Germany that disappeared in 1990 was a polluter on a quite heroic scale, above all through the burning of lignite. Coping with the after-effects of that, including the financial costs of clean-up, remains part of the larger landscape of energy decisions in united Germany. Secondly, the paper notes both the controversial status of nuclear energy in Germany, compared (for example) with France, and conversely the exceptional zeal with which the development of renewable energy sources has been pursued. Both of these phenomena are related in turn to a third issue, namely the extraordinary salience of "green" issues within German politics, on this as on other environmental issues, which goes beyond the existence of a strong Green Party to the broader purchase of environmental concerns in German culture and society.

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Abstract

This paper is mainly concerned with the changes in energy regimes in Germany. It begins with the shift from a pattern of water-power coupled with wood- and peat-burning (the so-called solar energy regime, because it depended on the energy fixed in trees, peat and the plants that fuelled animal and human muscle power) to wholesale exploitation of fossil fuels, first coal, which still provided more than 90 per cent of German energy needs in the 1930s, then the oil that became essential to the mature industrial economy of the twentieth century. It then examines three other sources of non-fossil energy that emerged in the last century: hydro-electric power, or "white coal", nuclear power, and the many forms of renewable energy like PV, biomass, solar and wind power, some of which had much earlier advocates, both before and during the Third Reich.

The paper aims to show how, beginning with the coal-based industrializing economy, different forms of energy attracted both passionate supporters and equally passionate critics. Particular attention is paid to hydro-electric power. "White coal" was presented as a cheap, clean, renewable and above all "modern" source of electricity that would challenge the power of the coal barons and solve a variety of social problems. Critics argued that many of these claims were hyperbolic and could not withstand scrutiny; nature conservations noted the aesthetic and ecological costs of the dams that provided hydro-electric power. This was in many ways a foretaste of the fierce debates about nuclear power in the postwar Federal Republic, for advocates of nuclear energy possessed an almost messianic belief in a supposedly cheap form of energy produced by men in white coats - although one of the several ironies brought out in the paper is that some conservationists in the 1960s welcomed nuclear power as an alternative to the construction of dams that damaged the natural landscape.

In Germany at least, energy sources became powerful symbols within the culture, from "king coal" and "white coal" to the larger moral and social importance assumed by renewable energy sources in recent years. The paper brings out these larger cultural patterns. It also how energy choices and political power have been historically interlocked over the long term, noting especially the recurrent conflicts between small-scale and large-scale, centralized producers. As in other branches of environmental history, looking at the forms taken by the human domination of nature tell us much about the nature of human domination. The complexities and ironies of past debates about energy policy help to illuminate current arguments about the future of the nuclear energy industry, the promise of renewables and how quickly their share of total German energy can be increased, and the bearing of both of these issues on Germany meeting its pledges on CO_2 emissions.

Jean Jacquinot

Chairman of the Formation aux Sciences de la Fusion Federation
and since 2006 has been chairman of the ITER review group for heating
and current drive systems for experimental fusion reactors

He was born in 1939 in France, and holds a physical sciences doctorate in plasma physics from Orsay University. He studied magnetic confinement of hot plasmas at the French Atomic Energy Commission (CEA) from 1962 to 1982, making major contributions to the heating method now used in Tokamaks. He then moved to the Joint European Torus (JET) at Culham, UK, charged with creating the RF heating division, and constructing and operating the 32 MW RF power plant. In 1992 he became associate director and head of the heating and operations department at JET, and was scientific director of the 1997 deuterium-tritium experiments, achieving world records in fusion power output. In 1999, he became director of JET remaining there until the end of the Joint Undertaking and overseeing the changeover to a user facility. JET had a workforce of 600 and an annual budget of 77 million Euro, and was the largest magnetic confinement facility in the world.
In 2000 he returned to France to head the Euratom-CEA association and CEA group concerned with controlled fusion research in Cadarache. He supervised the upgrade of the French Tokamak Tore Supra for long pulse operation which in 2003 outputted 1000 MJ in pulses lasting over 6 minutes. In 2004 he became scientific advisor to the High Commissioner for Atomic Energy.
He has published 350 papers, given 30 invited lectures, and is co-author of ITER: l'énergie des étoiles? He is Chevalier de l'Ordre National du Mérite and Chevalier de la Légion d'Honneur. He has medals from Aix-en-Provence and Saint-Paul-lez-Durance, won the Chercheur de l'année, prize awarded by Le Nouvel Economiste, and the Duc de Villars prize from the Académie de Marseille.

Abstract

The case for a world collaboration on fusion and ITER

During this century, most countries world-wide will face the major challenge of scarce energy supplies combined with the necessity to preserve the environment for future generations. Growing energy demand will be confronted with the inevitable decline of gas and petrol resources which contribute presently to 62% of the total energy supply. Coal represents about 25 % but its consumption is presently increasing. This raises further the formidable difficulty of preserving the environment as the release of CO2 in the atmosphere is already excessive. In order to meet the challenge, it seems unavoidable to moderate energy consumption and to increase our R&D programme for a combined and optimized usage of renewable and nuclear energies, including both fission and fusion.
The present fission reactors have the great advantage of avoiding greenhouse gases and other atmospheric pollution. However, they require strict management of radioactive fission products over very long periods and, in view of the known uranium resources, could not satisfy the total world needs for very long.
Fusion energy would, when available, keep the same advantages but, in addition, would offer an essentially limitless fuel supply and a much reduced waste storage problem. It is therefore very tempting to reproduce on earth this energy which has powered our sun for five billion years. It however requires solving a number of scientific and technological challenges before considering an industrial development.

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Abstract

An international collaboration of unprecedented size is being set up in response to these challenges. The ITER project is the main element of this effort. It aims at the scientific demonstration of fusion energy at the level of 500 MW using a Tokamak confinement device. It will also test key fusion technologies, most notably super conducting magnets creating the confining magnetic field. On 21st November 2006, seven large countries or federations of countries (China, South Korea, United States of America, Russian Federation, India, Japan, and European Union) signed in Paris the ITER agreement for constructing and operating together this very large facility. Consequently, 33 countries representing more than half the world population and more than 75% of the gross world product are directly involved in this project.

Cadarache, in the South East of France, has been chosen as the construction site. The growing international team, presently in excess of 250 people, is on site coordinating actively this vast enterprise. The ITER developments in such a positive atmosphere of international collaboration are a clear sign of the realization of the risks associated with intensive use of fossil energy. This is a good step on the way to a world energy policy and also shows the importance of science for the future of mankind.

Fulvio Conti

Chief Executive Officer and General Manager of Enel S.p.A.

Fulvio Conti (age 59) is Chief Executive Officer and General Manager of Enel S.p.A., the Italian energy group, a position he has held since May 2005. He became Chief Financial Officer of Enel S.p.A. in 1999.

Fulvio was formerly General Manager and Chief Financial Officer of Telecom Italia and between 1996 and 1998 was General Manager and Chief Financial Officer of Ferrovie dello Stato, the Italian national railway.

From 1991 to 1993 he was head of the accounting, finance, and control department of Montecatini and was subsequently in charge of finance at Montedison-Compart, overseeing the financial restructuring of the group. Fulvio began his career in 1969 with the Mobil Group, where he held a number of executive positions in Italy and abroad, including a period as Chief Financial Officer for Europe. He is Non-executive Director of Barclays Bank since 2006.

Abstract

Energy supply equation.

Today's energy supply context is characterized by:

- Call for emissions reduction;
- Increase of energy demand;
- Limited amount of resources.

We must address a challenge with three facets: guarantee enough and secure energy supply, at a reasonable price, respecting the environment.

This is the apparently impossible enough + safe + clean energy equation. Single actions alone cannot solve this equation.

With a global, comprehensive approach, we can win the energy challenge.

The international scientific community generally agrees on the correlation between global warming and greenhouse gases emission.

In 2004, 26.100 mn tonn CO2 were emitted. According to the IEA, emissions will rise by 55% reaching 40.400 mn tonn by 2030.

Emissions in Brazil, China and India will double, reaching 1/3 of overall emissions. Every year CO2 emissions in China rise 8 times the annual reduction that Europe would achieve in order to meet Kyoto objectives.

Further to the Kyoto Protocol commitments, the European Community has already set the targets for 2020:

- Reduction of 20% of greenhouse gases emission vs. 1990 values (the Kyoto Protocol set a target of -8% by 2012 vs. 1990 emissions);
- Increase of demand side energy efficiency, in order to save at least 20% of primary energy;
- Increase in the production quota of renewables, up to 20% of total energy consumption, which translates into c.35% of total electricity consumption;
- Increase of biofuels' usage for transportation.

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Abstract

Forecasts for energy demand reflect an increase in CO_2 emissions.
According to the IEA, in 2004 the energy demand was 12.2 Gtep and is estimated to rise up to 17.1 Gtep by 2030. The increase in demand will be higher in developing countries, which will roughly double their demand, while OCSE countries will increase their demand of primary energy by an additional 25%.
The increase in energy demand has a strong influence on external supplies' needs.
In 2004, Europe imported 64.7% of fossil fuels necessary to meet its energy demand (gas, oil and solid fuels). This quota is expected to rise to as high as 83% by 2030.
In 2004, Italy imported about 92% of its needed fossil fuels, with estimates that set this number at about 99% by 2030.

1. SECURITY OF SUPPLY

Demand for primary energy is growing. Europe is increasingly dependent on external sources.

In this context, to guarantee the security of energy supply, the following elements are necessary:

- A common strategy among European countries.
  The challenge can not be dealt with effectively by 27 independent micro-markets. Instead, we should encourage the creation of large energy players, to further leverage both economies of scale and stronger negotiating power with large suppliers.

- New gas supply routes.
  Building pipelines to better connect Europe and transit countries, including those which make up the vast Mediterranean areas, is of paramount importance. This also applies to new regasification units, which allow the diversification of available suppliers by using LNG carrier ships.

- Diversification of the fuel mix.
  Reducing the dependency from the major oil- and gas-producing countries, also through the development of renewable energy sources, is crucial.

Abstract

Zooming into the Italian context.

- Italy produces 44% of its electricity from gas, a percentage which is double the EU 15 average. As a result, Italy is even more dependent than Europe from external sources of energy.

- In this context, Enel is undertaking a thorough program of rebalancing of its production mix, with the objective of increasing the share of its electricity's production from coal to 50% (from today's 25%).

- Enel is indeed strongly committed to developing clean coal technologies. To this end, Enel has invested Euro 1.6bn for the construction of a 1,980 MW high-efficiency coal plant near Civitavecchia, and has earmarked an additional Euro 1.8bn for the construction of a second high-efficiency coal plant near Porto Tolle.

2. COMPETITIVENESS

Competitiveness in the energy sector revolves around three main factors.

Size (economies of scale).
- Low concentration of the European power sector. Larger, integrated operators are necessary to reduce production costs and improve customer service.
- Growth through trans-national investments.
- Stimulate the elimination of political barriers against the free movement of capitals to favor the creation of "European champions".

Diversification of production mix.
- Investments in innovative technologies (e.g., hydrogen, coal gasification, carbon capture and sequestration, etc.).
- Renewable energy sources: new solar projects (thermodynamic), wind and geo, etc.
- Nuclear: increase capacity and safety of existing plants and develop new ones.
- Demand side efficiency: customer-oriented, cost-effective technologies (e.g., smart grids, distributed micro generation, etc.).

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Abstract

A Pan-European market.

- Favor the creation of one single European market, or at least macro-regional markets.
- Encourage the creation of a European agency to oversee the functioning of national TSOs.
- Deploy new technologies to allow innovative, quality-oriented and cost-effective solution for customers.
- Promote the harmonization of regulations across different countries, in order to eliminate disparities.

3. ENVIRONMENTAL SUSTAINABILITY

Global actions must be taken to address the climate change issue.

Global approach.

- Include developing economies.
- Existing and innovative technologies should be transferred to developing countries where they can have a larger impact.

Renewable energy sources and clean technologies.

- Renewable energy production must be increased by building new facilities and promoting research and innovation.
- Up-to-date technology must be extensively deployed to increase production facilities (supply side efficiency), efficiency and reduce emissions.
- Demand side efficiency must be encouraged. Energy saving is the first energy source.

Research and innovation.

- Investments in research are also crucial both to make traditional technologies cleaner…
- …and to find innovative ways of producing, storing and distributing energy.

CONCLUSIONS

- Adopt a common European strategy to assure security of supply.
- Encourage the creation of larger European/global integrated operators to achieve economies of scale.
- Invest in nuclear, new technologies and renewable energy sources to diversify the fuel mix, thus reducing costs and dependency from fossil fuels.
- Promote the creation of a set of clear long-term regulatory frameworks to increase investments' attractiveness.
- Support the creation of a pan-European market and the conditions for its functioning, harmonization of regulations and TSOs coordination among interconnected countries.
- Address environmental sustainability and climate change, deploying new technologies, investing in renewable energy sources and research, stimulating a global approach, involving developing economies.

Giuliano Amato
Italian Minister of Internal Affairs

Giuliano Amato (born in 1938) was Full Professor of Comparative Constitutional Law at the University of Rome, School of Political Science, from 1975 to 1997, he had been Full Professor at the Universities of Modena, Perugia, Florence. Presently he is Global Law Professor at the NYU Law School and part time Professor at the EUI in Florence.
Member of the Italian Senate (since May 2001). Italian Minister of Internal Affairs (since May 2006).
Previous functions:
Member of Parliament from 1983 to 1994; Under Secretary to the Prime Minister's Office from 1983 to 1987; Minister for the Treasury from 1987 to 1989 and from 1999 to 2000; Minister for Constitutional Reforms from 1998 to 1999; Deputy Prime Minister from 1987 to 1988 and Prime Minister from 1992 to 1993 and from 2000 to 2001. He also headed the Italian Antitrust Authority from 1994 to 1997.
Former Vice-President of the EU Convention (from 2001 to 2003).

Education:
He studied law at the University of Pisa, where he graduated in 1960. Master's degree in Comparative Law at the School of Law of Columbia University (N.Y.) in 1962.
Publications:
He has written books and articles on the economy and public institutions, personal liberties, federalism and comparative government. His most recent publications include "Antitrust and the Bounds of Power", Hart Publishing, Oxford 1997, and "When the Economy is affected with a Public Interest", in F.Snyder (Ed.), "The Europeanisation of Law", Hart Publishing, Oxford 2000.

Participants of First World Conference on the Future of Science believe it of vital importance that the world community realises we are on the threshold of a new era of knowledge. Science impacts all fields of human life and explosive growth of knowledge in areas such as genetics, astrophysics and information technology will lead to an even greater influence on human activities.
Scientific knowledge offers us the possibility not only of improving the conditions of life for all, but also of radically changing the biological makeup of living organisms.
Humanity must be aware of the new freedoms and responsibilities these advances imply. Participants are also aware that this enhanced potential of science generates unanswered questions about its applications, and reasonable doubts about its possible misuse.
The signatories of this Charter believe science will continue to be vital for the progress and well-being of humanity; however the issues raised by scientific progress must fully and openly debated by the whole of society. They therefore undertake to:

1. Create an alliance for scientific development – involving scientists, philosophers, theologists, politicians, industrialists, jurists, and all interested parties – which will oppose the isolation of science by promoting constructive dialogue between all forms of knowledge that respect human identity and dignity. Maximum priority must be given to harmonising the scientific and religious world views, reconciling ecology movements and science, and inserting scientific issues into political programmes worldwide.
2. Actively reaffirm the humanism of science, its intrinsic spirit of tolerance and incompatibility with absolutism in all its forms. Only if it reasserts these principles can science and other fields of endeavour hope to continue pursuing the fundamental aims of promoting civilisation and protecting human life. While basic research will expand the horizons of knowledge, applied research must be concerned with goals that are essential for the future of humanity, including the eradication of poverty and hunger, reduction of child mortality, conservation of ecosystems and bio-diversity, elimination of pollution, improvement of energy efficiency and reduction of fossil fuel use, reduction of the toll taken by HIV, malaria and cancer, provision of water for agriculture and uncontaminated water for drinking.

3. Promote scientific thought and the scientific method as a way of investigating and understandingthe world, particularly among young people and in societies that have not attained an adequate level of material progress. The universal language of science and the rationality of the scientific method are unifying elements having the potential to bridge deep differences in culture, experience and faith, making constructive dialogue possible. The importance of encouraging interest in science in young children has been recognised by UNESCO, with its Declaration and Programme in Science and Technology Education.

4. Set up a permanent Authority for Science consisting of scientists, philosophers, theologians, industrialists, jurists, politicians and others, whose task will be to suggest the objectives and limits of scientific progress and to make rational proposals for the society of tomorrow. The Authority for Science will not be a group of super-technicians deciding in the name of all, but a committed team that systematically and conscientiously examines the problems posed and the opportunities offered by continuing scientific progress, and periodically submits its deliberations and conclusions to governments and public opinion.

Venice, September 23, 2005

The Third World Conference on the Future of Science is organized by

Fondazione Umberto Veronesi PER IL PROGRESSO DELLE SCIENZE

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Grateful acknowledgements to