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Energy and Sustainable Societies

Recommendations for ICSU from the Working Group on Energy and Sustainable Societies

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About ICSU

Founded in 1931, the International Council for Science (ICSU) is a non-governmental organization representing a global membership that includes both national scientific bodies (101 members) and international scientific unions (27 members).

Through this international network, ICSU coordinates interdisciplinary research to address major issues of relevance to both science and society. In addition, the Council actively advocates for freedom in the conduct of science, promotes equitable access to scientific data and information, and facilitates science education and capacity building.

The Council acts as a focus for the exchange of ideas, the communication of scientific information and the development of scientific standards. ICSU's members organize scientific conferences, congresses and symposia all around the world-in excess of 600 per year-and also produce a wide range of newsletters, handbooks, learned journals and proceedings.

ICSU also helps create international and regional networks of scientists with similar interests and maintains close working relationships with a number of intergovernmental and non-governmental organizations, especially UNESCO and the Third World Academy of Sciences (TWAS).

Because of its broad contact with thousands of scientists worldwide, ICSU is increasingly called upon to speak on behalf of the global scientific community and to act as an advisor in matters ranging from ethics to the environment.

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RECOMMENDATIONS FOR ICSU
FROM THE WORKING GROUP ON
'ENERGY AND SUSTAINABLE SOCIETIES'

Introduction: The Challenge of Sustainable Energy

Balancing the world's growing needs for energy services against our collective need for a healthy environment lies at the heart of the sustainable development challenge. Access to modern, reliable and affordable energy supplies is an essential prerequisite for combating poverty, but at present, at least a third of the world's population lacks access to even the most basic energy supplies and another third lacks access to reliable energy services. This greatly limits many societies' opportunities for social and economic development, and also underlies tremendous health problems resulting from reliance on 'non-commercial' fuel sources for indoor cooking and heating.

At the same time, the prodigious use of fossil fuels in industrialized and rapidly developing nations is responsible for an array of serious environmental and public health threats, ranging from indoor and local-scale air pollution to global-scale climate change. In the coming decades, it is expected that energy usage will steeply rise in the developing countries, as a result of growing demand from industry, transportation, agriculture, commercial and public services, and residential sectors. All nations bear responsibility to develop and adopt new approaches for meeting these demands while protecting ecological and human health.

The sustainable, environmentally-benign energy systems needed for the future will likely involve a diverse portfolio of sources. In rapidly developing countries such as China and India, large centralized energy production and distribution systems will likely continue to be needed. In many areas, however, small-scale, decentralized energy systems (including, for example, small gas turbines, hydro and wind power, biomass, and solar cells) will provide new opportunities for bringing electricity to remote areas, and for placing technological choices more directly in consumers' hands.

A significant and sustained commitment to investment in energy research, development and deployment (RD&D)[1] is a vital component of a long-term strategy to meet these challenges. The research carried out today will define the world's future energy technology choices. Currently, nearly all the world's public sector R&D is carried out by just a handful of industrialized nations. Collaborative RD&D with

[1] We refer to research, development, and deployment (RD&D) in recognition of the fact that these three areas of activity must be closely linked in order to make real progress. As discussed later in this report however, ICSU's true expertise is currently focused primarily within the realm of basic scientific research. Thus it will be necessary, at least initially, for ICSU to develop partnerships with other, engineering-oriented organizations that have expertise in addressing the challenges of developing and deploying new technologies.

developing countries is almost non-existent, and there is little support for capacity building efforts. The challenge is to do more than simply deploy existing energy technologies to the developing world. It is essential to engage developing countries as significant contributors to energy technology.

Important gains can be made by enhancing dissemination and implementation of existing technologies for energy efficiency, fuels cells, etc.; but it is widely acknowledged that no existing solutions are sufficient for meeting the tremendous, diverse energy needs of the coming decades[2]. Ongoing research is essential for developing technologically and economically feasible alternatives. This will require drawing upon the insights of 'basic' sciences such as physics and chemistry, as well as rapidly advancing 'applied' fields such as biotechnology, information and materials science.

Background for this Scoping Exercise

At the 2002 World Summit on Sustainable Development (WSSD), ICSU played a central role in identifying and promoting the role of S&T in meeting sustainable development goals. Fulfilling the promises made at WSSD is an important priority for ICSU in the coming years. At ICSU's 27th General Assembly (Rio de Janerio, 2002), the French and Japanese National Members proposed the creation of a major new interdisciplinary program focused on sustainable energy issues. This proposal was endorsed by the General Assembly, and as a first step, an *ad hoc* Working Group was convened to evaluate the potential opportunities for ICSU to become involved in this issue.

The Working Group held their first meeting in December 2003 in Tokyo, in conjunction with an International Symposium on 'Energy and Sustainability Science', hosted by the Science Council of Japan. A second meeting was held in April 2004 at the ICSU Secretariat in Paris. This report summarizes the Working Group's findings and recommendations, which will be incorporated into ICSU's broader strategic planning efforts. If approved by ICSU's Executive Board and General Assembly, the next step would be to develop detailed programme plans and implementation strategies.

Current ICSU Activities

There is, to our knowledge, only one ICSU Union activity currently underway that focuses specifically on the issue of energy - ICSU's International Union on Pure and Applied Physics (IUPAP) is carrying out an assessment of the status of all of the energy systems that have the potential to significantly reduce carbon emissions. IUPAP's efforts will undoubtedly be of great value and are applauded. We note, however, that

[2] For instance, a recent report for the U.S. National Academy of Sciences emphasizes that advancing hydrogen production and storage capabilities to the point where hydrogen economy can be a reality will require a "comprehensive, long-range program of innovative, high-risk/high payoff basic research" in catalysis, nanomaterials, membranes, and separation.

important perspectives could be added to such an exercise by other ICSU Unions, for example, IUPAC (chemistry) and IUBS (biology, especially biotechnology). Cooperative activities between ICSU Unions have been quite limited in the past, but ultimately, it is just these sorts of cross-disciplinary linkages that should be at the heart of ICSU's mission.

There are also several ICSU Unions with interests closely related to energy issues. For instance, IUTOX is interested in the health impacts of energy production, and IUGG deals with the geophysical systems that form the basis for most energy sources. Likewise, there are opportunities for linkages with activities of ICSU's Interdisciplinary bodies. For instance, the Earth System Science Partnership (ESSP) recently launched the 'Global Carbon Project' (http://www.globalcarbonproject.org/), which includes consideration of questions related to mitigation (or carbon capture from fossil fuels and storage) of carbon emissions and alternatives to the use of fossil fuels. ESSP is also developing interdisciplinary programmes in water, agriculture, and health, which all relate on various levels to energy supply strategies.

Overall, however, the current ICSU 'family' does not encompass the entire range of disciplines that are needed for a fully informed, comprehensive understanding of energy science and technology. Of particular concern is the relative lack of expertise in the realms of social science and engineering. Numerous branches of engineering are of obvious relevance; not only energy-related specialists, but also basic civil, mechanical, and electrical engineering sciences. Social science expertise is also of great importance, as some of our biggest knowledge gaps relate to the interfaces between society and energy systems, including public acceptance of new technologies and policies. This need to increase interactions with social scientists and engineers has been widely recognized as critical for many aspects of ICSU's work, and two primary strategies for meeting this goal are: (i) to build strong ties with other relevant organizations, such as the International Social Science Council and the World Federation of Engineering Organizations; or (ii) to expand the Union structure to entrain these disciplines directly into the ICSU family.

Energy needs and RD&D capabilities vary tremendously among different parts of the world. Fortunately, ICSU is uniquely well suited to meet the challenges presented by this diversity of needs. ICSU's National Members, representing 101 countries, could provide a valuable conduit for interacting with the appropriate experts and stakeholders in countries around the world. The interest of many National Members was made evident in a recent 'foresight analysis' carried out by ICSU's Committee on Scientific Planning and Review, wherein the countries of Belgium, France, Ghana, Jordan, Korea, Greece, Pakistan, Sri Lanka, Ghana, Macedonia, and Moldova all cited the issue of energy as one of the top priorities the research community in the coming years[3].

[3] Likewise, in the ICSU-commissioned evaluation '*Identification of Key Emerging Issues in Science and Society: an International Perspective on National Foresight Studies'*, energy is highlighted as a priority in national foresight studies from the governments of Australia, Brazil, Finland, Germany, Ireland, India, Japan, Peru, S. Africa, UK, US, Uruguay.

Proposed Future ICSU Activities

The Working Group members agreed that, given ICSU's ability to mobilize the vast intellectual resources of the world research community, there is a strong motivation for the organization to pursue the development of new activities related to sustainable energy. There are, however, several existing international organizations that already address various aspects of this issue (see textbox), including the assessment, commercialization, and dissemination of energy technologies. There is little rationale for ICSU to pursue activities that are already covered by these other organizations, unless ICSU's involvement would bring a distinct added value to the activity. We thus focused on identifying the niches that ICSU is uniquely positioned to fill. It was agreed that ICSU's 'traditional' strengths also apply to the energy issue. This includes the capabilities to facilitate new interactions among scientific disciplines, to strengthen international networks among national- or regional-level RD&D programmes, and to build bridges to relevant stakeholder groups beyond the scientific community.

Examples of organizations involved in international-level energy activities.

The World Energy Council (WEC)
The International Energy Agency (IEA)
The International Atomic Energy Agency (IAEA)
The International Institute for Applied Systems Analysis (IIASA)
The Inter Academy Council (IAC)[4]
Global Forum on Sustainable Energy

The general criteria that were used to select proposed activities include the following:

- The objective is to assess and inform RD&D needs and capabilities, not to advocate for particular policy choices
- The output of the activity must be of interest and value to a broad audience.
- There must be a high probability for success in securing funding and meeting project goals.
- The activity should not be something that is better covered by other existing organizations.

The Working Group suggests here a number of activities and focal themes that we believe may be particularly worthwhile for ICSU to pursue. It was decided that at this initial stage in the scoping process, it was best to suggest a variety of possible options. It should be emphasized, however, that given the Working Group's limited membership and resources, it was not possible to provide a comprehensive analysis of all possible realms of effective action. Thus the proposals listed here should be viewed only as *examples* of possible ICSU activities. Likewise, it should be emphasized that although these proposals focus only on a few particular types of energy sources or strategies, this does not imply that the Working Group favors these particular energy paths over others that are not explicitly mentioned.

[4] Energy is not a primary focus of the IAC, but the organization has recently proposed to carry out a major assessment of energy technologies.

A diverse range of activities are suggested, but they all recommend as a first step, some sort of initial workshop or assessment study that could be completed, as an *ad hoc* activity, within the timeframe of a year or less. It is possible that some of these initial activities could lead to larger, ongoing programmes. We recommend, however, that before committing to any such programmes, ICSU should pursue these initial *ad hoc* efforts, which will provide useful tests of the organization's ability to bring about tangible results, and to emerge as a highly-regarded presence in the realm of international energy RD&D. These initial activities will also provide valuable opportunities for ICSU to build an appropriate internal base of expertise, and to develop strategic partnerships with other relevant organizations.

The proposals are grouped into three related themes:

Removing barriers among different disciplines involved in energy RD&D. The field of energy science and technology tends to be highly segmented among specialists in different energy sources (fossil fuels, nuclear, solar, wind, etc), with little substantive interaction among these groups. There is a great need for 'neutral' platforms for interaction among experts from a wide array of backgrounds, where they have opportunities to exchange information and perspectives in a context that is free from biases towards any particular field of specialization. This is especially critical in the quest to develop integrated, mixed-use energy strategies.

Removing barriers to wider use of existing energy technologies. More widespread deployment and implementation of existing technologies for clean, efficient energy production and use is a vital prerequisite for achieving a sustainable global energy system. The sharing and dissemination of existing technologies among countries is often hindered by an array of economic, institutional and political barriers. Equally significant, however, are the 'social barriers' that result from inadequate understanding of cultural factors that affect public acceptance of new technologies.

Networking and integrating existing energy RD&D activities. Many large energy RD&D programmes are designed and operated at the national level. There are some potential benefits to international competition in the development of new energy technologies; but in many contexts, progress would be accelerated by strengthening cooperation and exchange of information among different national activities, and especially, by building stronger linkages to RD&D activities in developing countries. A politically independent organization such as ICSU can play a valuable role in facilitating such efforts.

Summary List of Activity Proposals

(note: These order in which these topics are presented does not imply a ranking or prioritization.)

Theme: Removing barriers among different disciplines involved in energy RD&D

1) End-use energy RD&D: Exploring efficiency improvements with a focus on energy services.

Theme: Removing barriers to wider use of existing energy technologies

2) An international scientific dialogue on the concerns of nuclear power generation
3) Facilitating technology adoption and diffusion in developing countries
4) Advancing techniques for production of alternative transportation fuels (i.e., ethanol) from cellulosic materials

Theme: Networking and integrating existing energy RD&D activities

5) Building global networks to advance technologies for carbon capture and storage, H_2 storage, and renewable H_2 sources

Proposal #1

End-Use Energy RD&D: Exploring Efficiency Improvements with a Focus on Energy Services

The objective of the proposed activity is to explore and assess efficiency improvements in energy end-use and provision of energy services. The patterns of energy end use and services depend much more upon the place-specific circumstances and conditions where energy is used than do the energy supply systems. When derived from a supply-side viewpoint, optimal technology choices tend to be more uniform, but when derived from a demand-side viewpoint (i.e. energy end use and services), a highly diversified system is likely to be the best approach.

A key concept in analyzing energy end use and utilization is that of 'energy services'. The ultimate purpose of the energy system, from extraction of primary energy sources through deliveries of final energy forms, is to provide affordable, environmentally begin and reliable energy services. Today, this is not generally the case with a third of humanity still without access to commercial energy services and another third without a reliable access to electricity.

The overall system is comprised of an energy supply sector and energy end-use. The energy supply sector consists of a sequence of complex processes for extracting primary energy resources (such as crude oil or hydropower), converting these into more desirable and suitable forms of energy (such as motor fuels or electricity), and delivering these secondary energy forms to places where the demand exists. The end-use part of the energy system provides services such as cooking, illumination, comfortable indoor climate, refrigerated storage, mobility and transportation, information processing and consumer goods and services. Energy services are the result of a combination of various technologies, infrastructures, labor, materials, and energy carriers. From the consumer's perspective, the important issues are the quality and cost of energy services. It often matters little what the energy carrier or the source of that carrier is. It is fair to say that most consumers are often unaware of the "upstream" activities of the energy system. The energy system is service-driven (i.e., from the bottom up), whereas energy flows are driven by resource availability and conversion processes (from the top down).

Therefore, the energy supply sector should never be analyzed in isolation: It is not sufficient to consider only how energy is supplied; the analysis also must include how and for what purposes energy is used. A more efficient provision of energy services not only reduces the amount of primary energy required but, in general, also reduces adverse environmental impacts and often also costs. At present, energy end use and provision of energy services are often the least efficient parts of the whole energy system. This means that it is also where largest efficiency improvement potentials are to be realized at least costs. New and advanced end-use technologies can help achieve these potentials but require dedicated RD&D policies and appropriate institutional frameworks.

The overall efficiency of an energy system is the result of compounding the efficiencies of the whole chain of energy supply, conversion, distribution, and end-use processes. In many instances, initial energy-efficiency improvements can be achieved through common-sense actions such as sealing leaking window frames or installing a more efficient furnace, or in the case of transportation, using mass transit rather than individual automobiles. After the easiest improvements have been made, however, the analysis must go far beyond simple energy accounting. Currently, the weakest link in most analyses of this chain of events is our understanding of the efficiency of various energy systems is the determination and quantification of energy services, mostly due to the lack of data about end-use devices and their actual patterns of use.

At the International Conference on Energy and Sustainability Science (Tokyo, December 2003), Professor Peter Pearson described a historical analysis of lighting services in the UK. According to his evaluation, the cost of lighting service in 2000 is one 350th of its cost in 1800, while the cost of fuel for lighting in 2000 is reduced to around one fifth of that in 1800. During this same time period, total lighting service consumption has risen 34,000 times; this dramatic increase was achieved primarily through increasing the energy efficiency of end-use lighting appliances. Similar types of historical analyses of energy services and technology transition have been carried out at IIASA that indicate very large future improvement potentials provided that new and advanced end-use technologies are developed and deployed. There are also many studies available on the limit of efficiency improvements in energy services; for example, analysis in thermal engineering, and thermodynamic analysis in physics and chemistry. The analysis of energy efficiencies with the second law of thermodynamics - so-called exergy analyses - indicates that theoretical efficiency improvement potentials for provision of energy services may be as large as a tenfold improvement compared to the current situation.

In general, however, most studies of energy systems focus on supply-side issues, and there is a relative vacuum of information about the end-use side of energy systems. It would be worthwhile for ICSU to seek to fill this vacuum by mobilizing researchers in the various appropriate disciplines of science and engineering. Through such collaborations, it will be possible to identify more efficient energy systems, and to enhance the provision of affordable and reliable energy services.

The proposed activities for ICSU are to review existing studies related to energy end-use and services, to collect historical analyses of the costs and efficiencies for providing energy services, and to review theoretical studies on the limit of efficiencies for providing such energy services. On the basis of these reviews, it will be possible to identify barriers to attaining maximum efficiencies and to foster the technological progresses needed to overcome these barriers.

The proposed study will enable the development of place-based energy end-use systems of high quality and reliability, affordable costs, and minimal burden to the environment. This is a far more comprehensive

perspective than can be obtained when only supply-side issues are taken into account. The knowledge obtained through a review of past developments in energy service efficiencies and theoretical studies on the limits of such efficiencies will provide insights for energy efficiency improvements, a key element of any transition to more sustainable energy systems. It will be particularly important to develop appropriate energy systems, including end-use technologies, for developing regions. The output of the proposed study will also be useful for the energy industry, where opportunities exist for new models of integrated energy service providers, using on-site energy systems such as fuel cells and cogeneration.

Participants in this activity must include senior scientists in energy systems analysis, energy technology assessment, and history of technology developments. Participation is also required from energy experts in developing regions and interested business sectors. Major audiences will be policy makers, business leaders, administrators for technology management, and related scientists and technologists.

Proposal #2

An International Scientific Dialogue on the Concerns of Nuclear Power Generation

It is proposed that ICSU organize an international scientific workshop focused on concerns about the potential for nuclear weapon proliferation arising out of nuclear power generation activities, and the consequent restrictions imposed on international nuclear technology exchange for peaceful uses. The objectives of such a Workshop will be to initiate a meaningful dialogue between the developed and developing nations, and to develop preliminary solutions for addressing these concerns.

Many leaders in developing nations view safe nuclear power systems as potentially important contributors to sustainable development strategies. However, most of the technologies and know-how for realizing this potential are primarily in the hands of the developed nations. Recent events have increasingly reaffirmed the serious reservations about the political commitment and the technological/managerial capabilities of the developing world to handle nuclear technologies safely and responsibly. The developed and developing world often hold opposing view-points on the complex and interlinked issues of nuclear safety, nuclear proliferation, long-term waste disposal, export control of strategic materials and technologies, physical security of installations and fissionable materials, etc. Though many of these views stem from differing political perceptions, several of them could potentially be addressed through objective scientific and technological solutions. Current research on proliferation-proof fuel cycles, new generation reactors with enhanced safety and proliferation resistance, improved safeguard and inspection systems, new physical protection systems that defend against terrorist interventions and intentional diversion efforts etc., are all aiming for science-based solutions to these concerns.

For all of these reasons, there is an urgent need to create a forum for discussion about participatory development of such systems and their eventual adaptation by all countries that operate nuclear power systems, research reactors, and strategic nuclear materials of all kind. The proposed Workshop would be a first step towards generating consensus among scientists and engineers from the developed and developing countries on a road-map for jointly developing and implementing technologies and systems to alleviate the present concerns regarding nuclear power generation. It is recognized that the scientists and engineers alone cannot ultimately resolve these differences, but once the scientific community has framed a unified strategy, it is likely to find greater acceptance among the political and administrative centers of power in all countries. To further such consensus building process, it would be essential that some of the main stakeholders both from developed and developing parts of the world be involved in the discussions.

In carrying out this initial task, it is important to consider the role of the International Atomic Energy Agency (IAEA). IAEA has a role in promoting peaceful applications of nuclear energy, as well as monitoring and controlling potential nuclear proliferation activities. However, the IAEA is increasingly preoccupied with certain specific national problems, and finds it difficult to focus on the subject of civilian

nuclear power in all its facets. While there are a few multi-lateral groups like the Nuclear Suppliers' Group (NSG), which concentrate on curbing nuclear proliferation, they are primarily political organs, and they pursue no direct activities aimed at promoting safe nuclear power, especially those with focus on the needs of developing countries. More importantly, there is also no specific international scientific activity, with broad participation, solely aimed at alleviating nuclear technology concerns.

The IAEA should be associated with this Workshop as an observer. However, considering the extremely contentious issues that divide the international community on this subject, progress can be expected only if a primarily scientific body, with high stature and international recognition of its neutrality, takes the leadership role in the initial phases and the initial debates are confined solely among scientists and technologists. In this respect, ICSU stands above other world bodies in its suitability to play the leading role. As an highly-regarded, politically-independent scientific body, ICSU will be capable of initiating a much wider discussion, where all countries may have greater faith in productively and openly debating their viewpoints.

In taking up this activity, ICSU will not only be filling a leadership vacuum, but also fulfilling one of its important stated missions: to mobilize the knowledge and resources of the international science community to provide independent, authoritative advice to stimulate constructive dialogue between the scientific community and governments, civil society, and the private sector. If initial discussions of these issues were organized under the aegis of ICSU, this could help to "break the ice" among the various parties involved, and the subject could possibly be pursued thereafter by other organizations (such as the IAEA), as appropriate.

A workshop as conceived above would likely result in a healthy initial dialogue between the developed and developing worlds on maintaining safe and secure nuclear power generation systems, and could lead to a clear understanding of the near and long-term scientific inputs needed to further abate current concerns. The initial understanding reached between scientists at such a Workshop can lead to subsequent constructive discussions at the political and administrative levels, and concrete steps towards international scientific cooperation and mutual assistance in this field.

Participants must include senior scientists and science administrators from the developed nations with technological capabilities and commercial interest in nuclear power generation, developing countries that have operating nuclear plants or have interest in setting them up, the appropriate scientific personnel from the IAEA , etc.. Special emphasis must be placed on ensuring the participation of national representatives who are senior scientists or technologists, who have a significant say in scientific decision-making in their respective countries regarding nuclear policies and nuclear power development.

Proposal #3

Facilitating Energy Technology Adoption and Diffusion in Developing Countries

More than half the world's population lives in rural areas, nearly 90% of them in developing countries. The vast majority of these people are dependent on working animals and traditional fuels -- mainly wood, animal dung, and crop residues – often-using primitive and inefficient energy conversion technologies. Reliance on these fuels for energy has a number of adverse effects; a) combustion of wood-fuels using inefficient technologies and appliances exacerbates deforestation and has downstream negative impacts on the rural environment and livelihoods; b) use of crop residue and animal waste for fuel can be to the detriment of soil quality and agricultural productivity, as these resources often have alternative applications as soil conditioners, organic fertilizers and livestock fodder; c) adverse health effects of indoor air pollution form the use of traditional fuels in confined and often poorly ventilated environments is significant; and d) lack of modern energy sources reduces the potential for achievement of structural changes that could lead to enhanced income-generating activities and the alleviation of poverty.

Since the 1970s, the World Bank, USAID, and many other development agencies have devoted tremendous effort and resources to promoting the adoption of new improved energy technologies in developing countries, with the view of alleviating the above problems associated with the lack of access to modern energy sources. This has included such activities as the promotion of stoves with improved energy conversion efficiencies and reduced indoor pollution, as well as encouraging and facilitating transition from non-commercial to commercial fuels. Yet to date, more than 30 years later, the levels of dependence on traditional fuels in developing countries have largely remained unchanged, the adoption of available improved energy related technologies has not taken place, and transition from non-commercial to commercial fuels has only occurred to meaningful extents in a few cases such as China and India. There are few critical reviews of development efforts made to date, and there is clearly a need to pause and answer the following questions before further interventions are undertaken.

Given the wide range of suitable technologies available, why has the level of adoption of improved technologies been so low? What are/have been barriers to technology adoption and diffusion?

To aid in answering these questions, it is proposed that ICSU commissions a study aimed at evaluating all North to South energy-related interventions that have taken place to date to establish the reasons for the apparent lack of success. The study should be conducted in two phases. Phase 1 should be a comprehensive literature review of all documented case studies to establish the view points of technocrats, scientists and policy makers that were/are involved. Phase 2 should be in the form of field visits to selected project implementation sites in developing countries (most likely in Latin America, Africa, and Asia) to arrange interviews and workshops with participant/recipient communities and their leadership. These activities will

be carried out with the assistance of local expertise and regional research institutions to be identified by the PI.

One of ICSU's stated goals is the mobilization of knowledge and resources of the international science community to identify and address major issues of importance to science and society. In the developing world, one such issue is the provision of energy for sustainable development. In order to provide authoritative advice and stimulate constructive dialogue on this issue ICSU needs to identify and gain in-depth understanding of energy related problems in this part of the world. The proposed activity will provide the fundamental data needed to make informed decisions. In fact, one could argue that the activity proposed here should precede any other energy related activity that ICSU may wish to support in the developing world.

The main deliverable for the study would be a comprehensive report that; 1) outlines the reasons for the low rate of adoption and adaptation of energy technologies in developing countries, 2) suggests possible solutions to the established technology transfer barriers, 3) suggest appropriate points, levels, or areas of intervention by the S&T community. This information would enable ICSU and other organizations to make informed decisions regarding future activities related to energy and sustainable development. The proposed activity may be the first such effort that focuses on evaluating development initiatives from the point of view of the end user. Anticipated potential participants include regional and national energy research institutions, and local communities that have previously participated in energy-related projects.

Proposal #4

Advancing Techniques for the Production of Alternative Transportation Fuels from Cellulosic Materials

Transportation in 2001 represented 57% of oil demand in OECD countries, 39.5% in the rest of the world, and has been growing steadily since 1970. The transportation sector accounts for 22% of all primary energy consumption in the world. By 2020, this sector will be the largest global emitter of CO_2, and will contribute seriously to the depletion of remaining oil reserves and threaten supply security. Attempts to face these problems have generally been tried along three distinct lines:

I. Shifting the structure of road transportations (passenger and freight) to less energy intensive transport modes;
II. Reduction of the energy intensity of various forms of travel improving engine efficiency;
III. Improving new conversion technologies such as the use of fuel cells or hybrid propulsion technologies.

Although there have been some successes, these approaches have been mostly ineffective thus far in reducing the thirst for petroleum distillates. In developed countries, efficiency improvements have a 'rebound effect' -- with better mileage and less fuel cost, drivers are stimulated to drive more or to acquire more powerful and energy intensive vehicles. In developing countries, per capita vehicle use is expected to increase dramatically in the coming decades.

Renewable fuels represent one of the most promising alternative strategies to face this problem. The use of ethanol-blended gasoline substantially reduces emissions of greenhouse gases, CO, VOCs, toxics, and particulates, thus helping to alleviate the problems of local/regional air pollution and global climate change. Efforts aimed at production of ethanol, as a replacement for gasoline, have been successful in a few places, most notably in Brazil and the United States. Present production of ethanol from sugar cane in Brazil is 15 billion liters per year, replacing one half of the gasoline that would otherwise be used in the country. Ethanol from corn in the United States has reached a production of 10 billions liters per year.

These raw materials, however, are not widely available in many countries, and thus could not provide a large portion of fuel to replace gasoline on a worldwide scale. The solution to this limitation is to produce ethanol from cellulosic materials, though acid or enzymatic hydrolysis followed by fermentation. There are several research programmes underway that are investigating technologies to make ethanol production from wood materials (including biomass waste) commercially feasible. However, this scientific and technical challenge has not yet been fully solved, and advancement of this work is often opposed by the oil industry and others with vested interests in non-renewable energy systems.

It is proposed that ICSU carry out an assessment of the state-of-the-art of woody material conversion to ethanol, with the purpose of identifying potential routes of process optimization, and the potential for expanding the use of alternative fuels in different regions of the world. Such an assessment would involve experts in various specializations of chemistry, physics, and biotechnology. It would involve social scientists and economists, to evaluate the socio-economic impacts of the use of such technologies in both developing and industrialized countries. It would also involve 'earth-system' scientists, to evaluate how the wide-spread use of cellulosic material as a major fuel source would affect ecological dynamics, land and water resource use, biogeochemical cycling, and other related factors. The outcome of this activity would be a detailed report on the status of the technology, its future prospects, and answers to question such as conflicting uses of woody materials and biomass in general.

Relevant research programs currently exist at the laboratory scale at NREL (Renewable Energy Laboratories) in the United States, CENBIO (Center for Reference in Biomass) in Brazil, and a number of small pilot plants in the U.S., Brazil, and Canada. The proposed activity could help to build networks among these existing efforts, and could expand the geographical and disciplinary range of experts involved in this work. The audience for this activity would be governments and private enterprises around the world.

Proposal #5

Building Global Networks for Carbon Capture and Storage, Advancing Technologies for Hydrogen Storage and Renewable Hydrogen Sources

Scenarios made by the International Energy Agency predict that by 2020, fossil fuels will still have to provide about 80% of the world's total energy consumption, contributing significantly to CO_2 emissions. In this context, three major options towards reducing CO_2 emissions are recognized: (1) improving the efficiency of energy production and use; (2) reducing the carbon content of fuels through increased use of natural gas and non-carbon fuels (e.g. renewables and nuclear); and (3) sequestering the emission of carbon dioxide. The third option is seen as a cost-effective medium-term strategy for achieving significant reductions in CO_2 emissions.

Furthermore, a long-term goal of many policy-makers and industrial organizations is to initially rely upon utilization of high carbon fuels such as coal, together with *carbon capture and storage* (CCS), for the large-scale production of hydrogen; and then eventually, to move towards a future where hydrogen is produced from a renewable resources such as solar, wind, hydro and biomass energy sources. The key to enabling this transition is to understand how renewable hydrogen energy systems work "in toto", as individual parts of the system are already under strong development. Research into the technological and control links between different parts of the hydrogen energy chain, and their interactions, is therefore of fundamental importance, and an emerging, though under-represented, area of work. In the long-term, however, large-scale storage of hydrogen would be the key to ensure uninterrupted supply of this fuel.

Research into low-carbon power generation, CO_2 capture and geological storage is fairly advanced. Most of this work is carried out by national, European or North American networks. Some of the major existing CCS research programmes include:

- EU Thematic Network on Capture and Storage (CO_2NET2)
- EU Network of Excellence on Geological Sequestration (CO_2 GeoNet)
- Canadian CO_2 Capture and Storage Technology Network (CCCSTN)
- US DoE Carbon Sequestration Regional Partnerships
- Australian Cooperative Research Centre for Greenhouse Gas Technologies (CO_2 CRC)
- Carbon Sequestration Leadership Forum (CSLF)

Hydrogen energy technology programmes include:

- UK Hydrogen Energy Network (H_2NET)
- EU Hydrogen Energy Thematic Network (HyNet)
- Norwegian Hydrogen Forum
- US DoE Hydrogen, Fuel Cells & Infrastructure Technologies Program ?

Although there may be individual contacts and links between the scientists involved in these various programmes, an organized global collaboration and networking of scientists (from developed and particularly from developing countries) has not been achieved. Furthermore, despite the well-recognized link between CCS and hydrogen production technologies, most CCS and hydrogen energy research programmes do not interact in a productive manner. Increased level of involvement by physicists, chemists, social scientists, and engineers would help to address the current knowledge gaps in CO_2 capture, geological storage, large scale hydrogen storage technologies, as well as addressing the risks, uncertainties and the public perception issues involved.

Being an independent international organization, ICSU could take action to widen the membership of these RD&D networks and be instrumental in setting up a global, collaborative research community. This would contribute to the goals of widening the scope of science research, mobilizing the knowledge and resources of the global science community, and reaching out to the scientists of developing countries, goals which are all central to ICSU's mission. The emphasis in setting up such a global network would be:

(a) on integrating the work of national and/or regional networks on CCS and Hydrogen energy technologies worldwide,
(b) on increasing the global interaction between the science and engineering communities for the advancement of knowledge beyond the current state of the art, and
(c) on facilitating a wider participation of scientists from developing countries.

As a first step, it is proposed that an assessment be carried out to evaluate the state of the art of existing technologies, and to identify national centres of excellence that have the potential to contribute and advance knowledge on CCS and Hydrogen technologies in the developing countries. The initial outcome of the assessment would be a report and proposed procedures for setting up a global research network to achieve the objectives listed above. The assessment would also identify the work to be carried out by identified national centres of excellence in the developing countries (such as source-sink inventories, characterization of storage sites and local sources for power and hydrogen generation.).

Funding of the Proposed Activities

Financial constraints are a primary consideration for planning any new ICSU activities. Initial progamme development work can often be supported by base ICSU operating funds and the work of voluntary planning groups. Inevitably, however, any major activities will require new, external sources of funding. At this initial scoping stage, it is difficult to determine funding requirements with any reasonable accuracy, but as a rough estimate, it is suggested that the activities proposed here may each require funding on the order of 100,000 USD.

National governments with interests in these issues, including regional governmental entities such as the European Union, would likely have interests in supporting some of the proposed activities. A wide array of private sector entities would also be quite likely to support such efforts; although if ICSU were to pursue this option, careful consideration must be given to potential bias and conflict-of-interest concerns. In addition, there are numerous intergovernmental organizations and private foundations that ICSU could feasibly approach for support if suitable proposals are developed. Examples include:

- The International Atomic Energy Agency
- OECD International Energy Agency
- World Bank
- UN Foundation / Rural Energy Enterprise Development Programme
- Sustainable Energy Finance Initiative
- Renewable Energy and Energy Efficiency Partnership
- Hewlett foundation
- Packard foundation

Science for Policy

Scientific research is a necessary component of society's continued evolution towards more sustainable energy pathways, but it must be acknowledged that scientific understanding alone is not sufficient to assure that these sustainable pathways will actually be pursued. Ultimately, much will depend upon the actions of politicians, industry, the media, and the general public. Enhancing interaction between the S&T community and these other societal 'actors' is always a worthy goal, and ICSU is in a unique position to facilitate such interactions. Thus, in addition to the specific activities suggested earlier, we encourage ICSU to continue serving as a 'voice for science' at international policy summits and other fora focused on energy issues.

One particularly valuable opportunity relates to ICSU's role as a lead representative for the S&T community in meetings of the Commission on Sustainable Development (CSD). CSD is the body within the UN System designated to review and monitor progress in the implementation of Agenda 21 and the Johannesburg Plan of Implementation. A major theme for the 2006/2007 CSD work cycle is 'Energy for Sustainable Development'. This is an important opportunity and responsibility for ICSU to ensure that an informed, even-handed analysis of future energy options is brought to bear on these discussions. We recommend that ICSU convene an ad hoc advisory group tasked with planning and coordinating ICSU's involvement in these upcoming CSD sessions.

Conclusion

As noted in the Declaration of World Conference on Science (1999, Budapest) science is primarily focused on knowledge creation, but there is also a great need for researchers to facilitate the practical utilization of knowledge that is created. Society is facing vast challenges that must be studied and addressed scientifically. Dedicated efforts to apply scientific knowledge will bring about great benefits to society and to the aims of sustainable development. It is an important and urgent task for ICSU to contribute to society's capacity for knowledge utilization, and the activities proposed here are seen as pioneering attempts to initiate this new type of research endeavour.

ICSU

International Council for Science

ICSU Mission Statement

In order to strengthen international science for the benefit of society, ICSU mobilizes the knowledge and resources of the international science community to:

- Identify and address major issues of importance to science and society.
- Facilitate interaction amongst scientists across all disciplines and from all countries.
- Promote the participation of all scientists–regardless of race, citizenship, language, political stance, or gender–in the international scientific endeavour.
- Provide independent, authoritative advice to stimulate constructive dialogue between the scientific community and governments, civil society, and the private sector.

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