Workshop Summary

Hydrogen and Governance

Exploring paths to a low-carbon society

16-18 October, 2005
University of Victoria

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Disclaimer: This report is based on an informal record of discussion as summarized by a variety of observers from the organizing committee. In its current form it has not been reviewed by workshop participants. Observations made and opinions expressed do not necessarily represent the views of any of the participants or any of the sponsoring or host organizations. Responsibility for interpretations expressed rests with the editor, who also acknowledges with thanks the work of Andrea Gemmill on this record, along with the contributions of all the organizing committee.

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IESVic
integrated energy systems

Executive Summary
Victoria Workshop, October 16-18, 2005

Centre for Global Studies

1. Overview

- This first workshop, as originally envisaged, centered on an exploration of the challenges involved in a social transition to a hydrogen-based economy. As the workshop program developed, the title of the event ("Hydrogen and Governance") was elaborated by the addition of a subtitle – "exploring paths to a low-carbon society". This broader context was reflected in the range of papers prepared for the workshop and in the discussion around them.
- The workshop consisted of three main segments – a keynote address by Ged McLean of Angstrom Power; three sessions outlining the evolution and current status of relevant technologies, and some implications (environmental, economic, cultural, legal) of social choices around large technological systems; and three sessions exploring the dynamics and challenges of such social choices, including institutional and procedural barriers. The last session addressed specific "crunch issues" meriting future work.
- The keynote address provided vivid illustrations of the dynamics of technological change, market opportunities and commercialization, and offered an energetic launch to the workshop with a stark reminder of the challenges of individual agency. Subsequent discussion in the workshop was animated throughout by this emphasis on the responsibilities we all carry personally in dealing with the dilemmas of collective action arising in the funding of research and choices among technological systems.
- Participants began by dealing with an assessment of the current state of hydrogen-based technologies, reviewed a range of likely future applications, and discussed the role which government might most constructively play in advancing the research, development and commercialization opportunities associated with hydrogen-based technologies.
- Participants expressed a range of views on the question of what role hydrogen would play in future energy systems in Canada. The differences often hinged on the timeframe under consideration. In addition to the evolution and sequencing of changing technologies over time, it was recognized that "mismatches" were likely to exist at any given time among a variety of factors, for example, the current state of the technology, the readiness of governments to address politically difficult energy issues, and developments in closely related fields (notably those affecting the environment).
- Participants also examined the more general questions of how science can best be translated into government policy, how to promote an inclusive policy generation process which adequately takes account of the perspectives of civil society, and how to ensure that Canadian decisions are both fully informed by international experience and trends, and contribute effectively to coordination

of activities within targeted international initiatives and official development assistance.

- In the final workshop session, participants were asked to group their concerns, observations and suggestions for future work under a number of general headings. Although the time available precluded an exhaustive compilation of ideas, this summary exercise provided the basis for the structuring of future work proposed below.

- The final session confirmed the richness of the information and views generated at the workshop. The diversity of opinion reflected the deliberate attempt of workshop organizers to bring together a lively, highly informed group with a full spectrum of backgrounds and interests. Under these circumstances, consensus was neither sought nor likely, but the workshop clearly achieved its stated purpose of highlighting specific areas where further research and policy formulation is required, as outlined below.

2. Themes identified

- The most striking feature, in retrospect, of the discussion of governance challenges to be faced in pursuing the goals of a low-carbon society is the number of different ways in which the international dimension figured in comments. Canada's responsibilities and potential contributions to international coordination of research and development, technology transfer and policy learning were frequently mentioned. Problems with implementation of the Kyoto Protocol and the creation of an effective post-Kyoto architecture highlighted the crucial importance of cleaner technologies open to adoption in developing countries—not just China and India, but across the vastly different settings of the developing world. Canada's opportunities to promote the direct take-up of newer, cleaner, more ecologically appropriate technologies without need for heavy social investment in energy infrastructure already destined to be succeeded (the 'leap-frog' option) were emphasized. This concern with the international dimension led to two new features in the program proposed below: the greater emphasis on regional workshops and consultation, and the proposal for involvement of participants from developing countries in the initial workshops in Canada.

- The Victoria workshop demonstrated the requirement both for a focus on the specifics of hydrogen-related developments and for placing hydrogen in the broader energy/environment policy mix (all in the context of the cultural diversity underlying Canadian institutional structures and processes of governance dealing with social risk and uncertainty). The policy debate should be anchored in the concrete hydrogen example, but accurately situated in the larger, operationally relevant governance setting. Although the conversation among technical, government, civil society, and private sector representatives may not be easy, such an inclusive approach is the only credible way in which usable public policy options can be developed for decision-makers.

- In this context and within the over-arching international dimension just mentioned, discussion in the final session suggested that the central policy

questions might be grouped under four broad themes: Timescales, technology and decision-making; Energy policy-making—governing instruments and federal-provincial relations; Local governments, local impacts, and cross-sectoral demonstration projects; Risk perceptions and safety standards—technological aspects of government decision processes.

3. Next Steps

- From the discussion at the workshop and the exchanges following, there has emerged a clear vision of a two-to-three year program, as outlined in the summary diagram attached, and a clear sense that the immediate next steps should be pursued now, with a near-term program for 2006, designed as the foundation from which the financing and organization of the full program can be developed.

- The full program, extending over two to three years as illustrated in the attached diagram, envisages a policy-oriented cumulative research program punctuated by a series of domestic and international workshops or conferences. At these periodic meetings, commissioned research papers will be reviewed and re-oriented by a core continuing interdisciplinary network augmented at each meeting by a diverse group of senior participants drawn from business, government, universities, research and civil society organizations reflecting the particular emphasis of the meeting. Toward the end of the program, the research emphasis will switch to focus groups and research exploring public perspectives and expectations, and to deliberative polling or consensus-seeking initiatives oriented toward possible recommendations for public policy at various scales.

- The near term program for 2006 envisages the commissioning of initial briefings on the current state of relevant technology (especially with respect to hydrogen-based technologies resting on nuclear or clean coal-based energy sources) and on the current state of related energy and technology policy. The first elements of this 'evergreen briefing book' will be reviewed in a first workshop to be organized at the University of Western Ontario in October, 2006, under the general heading of Timescales, Technology and Decision-making, with a focus on continuing technological evolution and related decision challenges. That discussion in turn is expected to build the foundation for a second meeting to be held at the University of Calgary. This second meeting, building on the results of the Western Ontario discussion, will be expected to examine more closely the nature of government expenditure programs, fiscal instruments, regulatory measures and educational initiatives in light of the many cross-jurisdictional and cross-scale linkages involved.

- Interim funding to maintain the current momentum and launch this initial near-term program without delay is being sought while the development of a broader consortium of funders from government, industry and foundations to support the full program is pursued.

I. Introduction

With increasing demands for fuel and electrical power, Canada will need the security and sustainability of alternative forms of energy. The use of hydrogen as an energy carrier is foreseen as potentially playing a critical role in future energy plans nation-wide. The projected 30 to 50 year transition to a low-carbon society will bring difficult decisions to Canada and Canadians. To ensure the fluidity of this shift, the coherence and effectiveness of technology and all forms of institutions is essential. The Institute for Integrated Energy Systems (IESVic) and the Centre for Global Studies (CFGS), at the request of the Social Sciences and Humanities Research Council (SSHRC), organized a meeting entitled "Hydrogen Governance: Paths to a Low-Carbon Society" held in October, 2005. This was planned as the first of a proposed two-to-three-year series of workshops with several objectives:

- To increase awareness and understanding of the many diverse challenges involved in a long-term social transition of this sort;
- To develop a continuing core network of people interested in bringing research and academic work into evidence-based processes of public debate and policy formation dealing with this transition;
- To highlight the importance of the human and institutional dimensions of technological innovation and industrial change, and to make adequate provision for research and animation in the human sciences in government programs supporting such a transition;
- To enhance international cooperation in development of mechanisms for knowledge management and exchange, information repositories and science archives with particular reference to social choices among large technological systems, with respect to low-carbon energy systems in particular.

This paper attempts to draw together the threads from the discussion at this preliminary October 2005 workshop on paths to a low-carbon society, in order to establish some sense of 'where to from here?' in an emerging work program. It proposes a rough framework that might be useful to stimulate an exchange of ideas leading to a plan for activities in an interdisciplinary network spanning participants from government, industry, the research community, and civil society broadly understood. That framework envisages the discussion in the initial workshop leading to a number of specific exploratory topics that can be categorized under six separate headings for more focused future work to be reviewed in more specialized meetings.

Discussion at the October 2005 worskhop began with an opening keynote address, delivered by Angstrom Power CTO Ged McLean. A brief summary of the general points addressed in each of the subsequent conference sessions is given below. Six 'bins' of initial suggestions as to the central 'crunch issues' to be faced are then laid out; these

might be goals that need to be set or clarified; challenges that need to be overcome; instruments or means to overcome them; or barriers to doing so. These lists suggest initial research agendas for working groups or commissioned analysis. Subsequent discussion may entail augmenting, correcting (or possibly putting aside) this starting frame.

A final section in this present report makes brief reference to three cross-cutting tasks underlying these 'bins', and suggests some interim conclusions from the workshop.

There is currently a great deal of ongoing research and development on the topic of alternative energies and hydrogen-based technologies within Canada and at an international level. The state of alternative energy in Canada is discussed in terms of Federal programs, provincial programs in British Columbia, and examples of research in university centres/institutes (see Appendix A). When making decisions regarding public policy issues, it is useful to take into account initiatives of other nations. Examples of alternative energy public programs in the European Union and the United States are briefly examined in Appendix B. Appendix C includes links to the archived participant conference session papers and Appendix D provides references to published and working papers posted on the live project website, www.h2governance.org.

II. Session Summaries

Session 1: What roles will Hydrogen play in a sustainable energy future?

Time-Scale Issues

There is a breadth of views on the question of what role hydrogen might play in future energy systems, but these differences often hinge on the time scales being considered. How far ahead and with what accuracy we can plan for social and technological change of this kind are limiting factors. The danger of misusing historical analogies must be considered.

These limits suggest the need to develop and maintain a wide suite of options, in turn requiring careful balancing and targeting of investment and policy. This is complicated by the mismatch leading to tension between the timescales of long term planning necessary for energy system and the shorter term need to address pressing challenges such as climate change, as well as the shorter-term mandates of governments.

Government Issues

Without active government intervention, hydrogen will not necessarily contribute to a low-carbon future. Is it possible to judge today whether hydrogen can play a significant role in carbon reduction strategies in the long term? How should governments lend support to this issue? Government support should vary in type and intensity depending on the level of development of a given technology.

In both the public and private sector, the amount of R&D funding available for hydrogen is relatively small compared to fossil fuels; energy industry expenditures on R&D are low relative to other industries. Hydrogen must be in a position to compete in the energy market.

Generally speaking, neither government nor public opinion is technologically well informed on the topic of hydrogen. Those involved must be attentive to the particular Canadian context: different countries are facing different challenges and opportunities (e.g. Canada vs. China). It must be asked whether there is a technology gap or a policy gap that is preventing the wider use of hydrogen - a serious question in terms of guiding policies.
A fundamental challenge is that of providing useful, effective advice to governments about how to proceed.

Session 2: What is the current state of the art and how will it evolve?
Technology issues

Hydrogen

The majority of vehicle equipment manufacturers foresee fuel cell vehicles to be available by 2015. In order for this to happen, basic science breakthroughs are needed for products to be cost competitive and ready for mass scale market adoption.
That said, some components are already deployable; small-scale fuel cell applications are deployable and can compete with existing battery technologies. Industrialized hydrogen production and use is currently a reality in Alberta, Canada – there is already an economy for C02 in enhanced oil recovery. There is a new demand growth for hydrogen production in Alberta, mostly due to tar sands. CO2 and H2 pipeline networks are in the near future. Infrastructure is not a major limitation. For instance, all urban centres are within approximately 200km of production/storage facilities.
Technologies are driven to be small scale due to the existence of regulatory and permitting bottlenecks. A challenge remains in bridging the gap between cost and volume (current OEMs are self-financing).
In China, energy security is the biggest driver. There is the potential for demand from that nation and this presents a driver opportunity for Canada. Other emerging markets, such as India, should be considered.

Carbon Sequestration

Carbon sequestration is perceived to be a serious contender in hydrogen production and is deserving of attention (albeit some view that it is not a solution in itself to the energy system). Issues of feasibility, deployability, and the long term proof of geological security must be taken into account.

Nuclear

Nuclear energy is also perceived as a major segment in the future of energy, although there is disagreement over its long-term implications, as well as debate over its cost competitiveness. Clean coal technology and renewables, such as wind, were also discussed.

Governance Issues

Is capitalism compatible with a sustainable future? (renewables cannot support indefinite economic growth) The barriers to hydrogen rich fuel systems are governance issues and regulations. There are two strategies from which to start: firstly, large scale emitters (minding that automobiles only account for approximately 16% of total emissions) and

large demand centres, with the goal being C02 reduction. Secondly, from a small-scale counterpoint; the role of small scale technology solutions (central generation of electricity is evolving into distributed generations, mostly due to transmission limitations (e.g. EU countries). Backlash issues were raised. There is uncertainty whether hydrogen will necessarily lead to a low carbon path come production end.
Current subsidies of the oil economy create an unfair playing field for other energy options, the cost of carbon emissions not included. (note – nuclear was not cost effective when first started, now is (close?) Subsidies for managing the end of cycle issues have not been accounted for. Competition for R&D funding dollars is an issue. Hydrogen may not directly compete against other fuel technologies, but it does compete for energy and other industry funding.
Management options were also discussed, resulting in the following suggestions:

- fiscal incentives/disincentives
- carbon taxes
- caps
- demand management route
- buying time -- starting with cost effective options

Session 3: What are the economic, political, legal and cultural challenges of moving toward a sustainable energy future?
There is a lack of a clear niche for hydrogen, which is unrecognizable without government intervention. The inertia of incumbent technologies, industries , economies and political relationships can be a barrier but can also evolve to create synergies with hydrogen energy technology, for instance the role of nuclear energy in alleviating climate change.
Public understanding of key reasons for change is not at a high enough level on topics such as security, health and global warming. A vision needs to be created for the public, decision-makers, government officials and investors that is both inspiring and actionable. An understanding of available solutions and strategies for public education is necessary. Is an energy crisis required for steps to be taken? The lack of federal/provincial cooperation must be rectified for effective action to occur.
Is there a need for Canada to develop, a national energy strategy or a continental energy strategy and/or effective mechanisms for international coordination (i.e. leveraging)? Disagreement among experts is leading to the loss of legitimacy regarding the call for new policy. Will Kyoto serve as an obstacle to hydrogen advancement or will Kyoto serve as a useful first step?
Canada is lacking a low carbon culture. All involved need to rethink policy, procedures and institutions to take into account the impact of consumerism.

Session 4: What are the barriers to translating science into policy?
Time scales
New technologies sometimes require policy innovation; new policies present new risks. Misinterpretations of risks are difficult to overcome, exemplified by negative attitudes towards the nuclear industry. If proponents of hydrogen energy are serious about engaging the public, serious investment required.
Two barriers to a low carbon society were identified:

- Policy/decision makers' lack of understanding and mistrust of the public
- Institutional
  - media – slashing budget for S&T coverage
  - senior policy makers lacking technology background
  - organization of Canadian government cannot handle cross-cutting issues

Governmental time scale does not match with the urgency of problem; problems need to be framed so policy/decision makers can see relevance to the issue in their own time frame. Economics can not always lead policy decision-making processes.
In deconstructing science and policy, policy must lead but science can help. Science influences policy, which influences the type of science that receives funding. Scientists have a limited ability to 'sell' their decisions independently.
But, relying on a technological fix for social problems may alienate the public.

Involvement of Citizens/Public
How and when to engage the public must be considered. Is engagement needed at all in some situations? Once consulted, how can public views be transformed into policy (process)? The definition of "public engagement" varies – engagement vs. consultation, opinion mining vs. education, quality. Are there specific models that can be followed? For example, the nuclear industry public engagement process is lengthy, costly and intensive. Values and trade-offs must be examined.
Public consultation provides special insights, but complex issues are not always well absorbed by the public, therefore 'leading' may be required. The public may not always accept the outcome but it is important that the process is accountable and trustworthy. Trust and confidence are key to social acceptance.
Panicking the public into fast action may have adverse effects

Risks
What requirements do specific technologies have to live up to considering the varying values and desires of Canadian society? What trade-offs are people willing to accept? The human element in technology is a major element of risk.

Others
Distributed systems are at a scale that may better involve people than would large-scale centralized systems.

There is the possibility of regulatory failure, not necessarily market failure.

No coherent packaged energy or climate change strategy exists that can be delivered to the public for feedback and consultation. Regarding climate change, the public does not trust that any political action will follow any strategy formation.

Session 5: What roles should government, industry, civil society and universities play to enable a sustainable energy future?
Potential components of a government role in fostering progress towards a low-carbon society include the following: developing meaningful consultation; adjusting the tax system so as not to overly privilege incumbents; developing a medium to long-term

research portfolio; contributing to and taking full advantage of world scientific literature; developing standards appropriate for a large, sparsely populated, cold climate country. Governments need to begin thinking seriously about a carbon tax ; the use of nuclear technology in connection with the tar sands; and work internationally to prepare for the post-Kyoto world.

There is a need for a vision and a related long-term plan with regional, national and international aspects. A thorough systems analysis, which includes both technical and social factors, is necessary. New organizing structures within which to motivate people to achieve the vision must be set in place. Meaningful dialogue with affected communities is essential. Note that 75% of energy is consumed in cities – mayors and other civic leaders must be more directly involved in policy making

It is impossible to predict the future accurately, but action must be taken. National mobilization is needed in the face of climate change. It is important to set understandable goals, to take short-term measures immediately, and to lay the foundation for the needed longer-term approaches.

Priorities and actions must be informed by the timeframes of the technological solutions; global warming will change the energy services required by society. An integrated approach must be taken to design. In so doing, Canada should mobilize an international collaborative research agenda.

The urban built environment must change; warnings of the threat must be kept credible if adaptation is possible and/or likely. The broader community has not bought into the idea that global warming represents a crisis, or if they have, they have come to believe that there are no solutions. An overall, credible package of responses is thus required.

Universities have too little involvement in policy-making processes. Current university practices limit the degree to which they can contribute to public policy development and implementation. Universities must also expand their mandate as knowledge suppliers to include the role of first users of technology.

The sources and speed of research funding were also discussed.

Session 6: Next steps – "Crunch issues" for future consultation and deliberation.
This exchange of ideas through the workshop suggests that there are half a dozen components of the discussion that warrant more research and more truly inclusive and interactive social engagement (not fake consultation).

These components of a future work program might be organized as follows:

1. Technological evolution and sequencing
2. Safety concerns, risk perceptions, regulatory frames and standard setting to address risk concerns
3. Federal-provincial concerns, regulatory harmonization, cross-jurisdictional management, international coordination, institutional gaps
4. Industry programs, R&D support, infrastructure needs and public goods; coherent use of economic instruments, insurance barriers; economic regulation
5. Local governments and local applications, demonstration projects; confronting NIMBY

6. Citizen engagement, legitimate decision processes; confronting NIMTOF

Most of the suggestions for research or policy action could be organized under these headings.

1. Technological evolution and sequencing, as noted briefly above:

A. Action Items

- Establish a stable continuing budget to support the broad range of basic research needed to enable development of the technologies needed ultimately to introduce hydrogen-based energy systems and a low-carbon society;
- Establish a more balanced portfolio of federal support and expenditure on hydrogen technologies, alternative fuels and other programs outside the existing programs so heavily oriented toward hydro-carbon fuels.
- Create, probably at the federal level, the institutional capacity for ongoing systems analysis.
- Promote interdisciplinary networks and meetings, perhaps through SSHRC/NSERC/CIHR programs partnered with NGOs.
- Given the many roadmaps developed to describe the evolution of a range of different technologies, consider the development of a meta-Roadmap that could bring the sequencing of developments into an accessible integrated 'evergreen' living document or rolling plan, updated as new knowledge and information on innovations becomes available. Could such a meta-roadmap be interpreted as capturing some agreement on a general vision for social transition in this field?

B. Research Questions

- The nature of a massive R&D program required, including basic theory and modeling in materials science, for example with respect to safe and secure storage needs. [Suppose we had our wish, as above; on what should/would the money be spent??]
- We have, at the moment, a very brittle supply system; vulnerable to shocks; we need something much more resilient – how could such a system be developed?
- Massive and diverse very long-lived infrastructure requirements for the overall production, storage, distribution, service system represent a serious capital barrier to entry; how can this 'chicken and egg' problem be overcome without giving up the essential dynamics of decentralized decisions within a market-based system?
- In response to those barriers, the possibilities of beginning a transition to a hydrogen economy with a move early to distributed systems, with later development of more centralized production and storage if economic and commercial realities dictate, has been advocated; how could such a transition be facilitated?
- Explore existing capacity for production of hydrogen, and examine both opportunities for using existing excess supply and the potential for expansion of production capacities.
- How can carbon sequestration and storage be built into the process of technological transition to extend the effect life of existing hydrocarbon fuel

sources while contributing to attainment of goals with respect to emissions reduction and adaptation to anticipated climate change?

- Explore the commercial realities associated with 'pluggable hybrids' as one way of using electricity to fuel transportation and build acceptance of alternatives to combustion engines;
- Technologies for the production of hydrogen; recognize hydrogen as a carrier to store electricity produced by any means; how to make all this more efficient?
- Is it true that we "Cannot solve the GHG challenge without nuclear production"?
- In what direction should technologies for negative emissions be developed?
- Need to explore the dynamics of development/diffusion/adoption cycles further to identify opportunities for government intervention and facilitation consistent with the technological realities?
- More research is needed to address crucial features of 'scaleability' challenges.
- The technological dimensions of investments in rebalancing electrical grids, distribution systems, pipeline networks, need research now.
- Footprint analysis of various low carbon strategies?
- Examine the institutional adaptations in the research funding applications processes necessary to reduce the present massive barriers to developing proposals for such programs.
- A particular research theme: cost-effectiveness of wind power (taking account of the need for rebalancing of electrical grids and other infrastructure adaptations - necessary if large scale contributions of wind power to production of electricity is to be feasible);
- More generally, explore the substantial infrastructure requirements for the many interface structures that will be required to bring a range of alternative energy sources into an integrated carbon-neutral energy system.
- Comparative study of full life cycle analyses of competing complete energy systems (perhaps on the model of the well-known Inhaber analyses, but with greater research collaboration in order to aim at greater acceptance of the analysis?)
- Specific case studies of integrated analyses to test the feasibility of achieving any such agreement?
- Document case studies of successful penetration of particular market niches (such as small batteries) by fuel cell technologies, in order to explore the characteristics affecting social acceptance.

2. Safety concerns, risk perceptions, regulatory frames and standard setting to address risk concerns

A. Action Items

- To promote development and greater public acceptance of hydrogen fuel cell based technologies, invest in construction of demonstration projects for large facilities at fixed sites and document the experience as serious historical or anthropological case studies.

- Address institutional difficulties of standard setting, representation in the technical, regulatory and political processes of standard setting.
- Public acceptance issues paramount in standard setting exercises should be explored and documented to assist technical personnel.
- If it is accepted, as was asserted several times in the meeting, that any significant move toward a hydrogen economy would entail substantial appeal to nuclear power, then all the well-known difficulties associated with widely diverging perceptions of risk, and massive barriers to public acceptance, will have to be revisited as central social dimensions of regulatory policy and energy strategy. For this purpose, the nuclear industry itself will have to engage more directly with increasingly influential NGOs. Might a program with the NWMO, along the lines of its present work on waste disposal problems be commissioned by governments to address public concerns associated with the use of nuclear energy to produce hydrogen at a large scale?
- Academic engagement with NGOs should be a feature of studies and policy initiatives addressing this challenge with respect to nuclear energy in particular, and social transition to low-carbon technologies in general.
- Nevertheless, it will be crucial to steer the 'hydrogen agenda' as far away from any association with the nuclear industry as possible.

B. Research Questions

- Risks associated with technologies for carbon sequestration and storage will encounter probably greater public question than those associated with hydrogen fuel cell technologies; they should be explored in greater detail.
- The vast general literature on the treatment of risk, uncertainty and ignorance in the policy formation process should be brought into application to the specific cases of the technologies at issue here; the literature on boundary organizations and boundary work to facilitate the utilization of science and scientific evidence should be pursued with reference to these tasks. Could the network proposed below be seen as a useful boundary organization for these purposes?
- As part of the federal Smart Regulation initiative, document the full array of regulatory requirements (barriers) surrounding development and introduction of hydrogen technologies, examining opportunities for greater transparency, reduced overlap and duplication, inconsistency, conflict, and inadequate public communication.
- Study the institutional changes needed to ensure that risk assessment processes 'start from where the folks in the community are' rather than ascribing positions drawn from central government theories.

3. Federal-provincial concerns, regulatory harmonization, cross-jurisdictional management, international coordination, institutional gaps

B. Research Questions

- The very special circumstances of Canada as a small country with an extensive range of vast resources from which to choose its responses needs to be explored

and emphasized in considering a global transition to more sustainable energy systems;

- The importance of urban and regional development strategies, reflecting these particularities, needs to be emphasized;
- The opportunities for Canada to lead in efforts to assist developing countries to leap-frog some of the problems of a massive embedded hydro-carbon dependency in industrial structure need to be noted and assessed as part of Canada's general goals in contributing to global development while carving out a special role for Canadian expertise and intellectual property in technologically advanced spheres;
- The risks and opportunities offered by development of new energy production and distribution capacity within an integrated continental framework need to be explored, with reference also to the leverage offered for Canada in the international sphere.
- Undertake systematic assessment, on a comparable, full life cycle basis, of the range of alternative technologies proposed as replacement technologies at various stages in the transition process (such analysis was also proposed under the first heading).
- Develop retrospective studies to draw lessons from past experience with attempts at regulatory harmonization and administrative delegation in energy-related fields.
- Look to the regulatory determinants governing the twinning of hydrogen production with energy storage.
- Look to the impacts on adoption of alternative energies resulting from particular settings of the buy-back prices in electricity grids(?)

4. Industry programs, R&D support, infrastructure needs and public goods; coherent use of economic instruments, insurance barriers; economic regulation

A. Action Items

- Increase the R&D budget dramatically, explore institutional innovations to create stable settings with adequate slack, within which research efforts can be guided by a long-term, arms-length vision and research plan (keep the auditors at bay for a while);
- Develop government procurement policies and practices to facilitate innovation and diffusion and to support penetration of Canadian technologies in international applications.
- Pursue the practical tactics of a substantial carbon tax that can be implemented, perhaps, for example, through a commitment of a transfer of half the revenues to Alberta to support an innovation agenda (or perhaps ploughed back directly to consumers).
- More ambitiously, design a carbon tax sufficient to assure the attainment of targets sufficient to stabilize atmospheric concentrations of CO_2 below agreed target levels, and animate extensive public debate about a feasible timetable for attainment;
- Develop a horizontal management plan by which each federal department is required to elaborate the measures by which it can contribute to an overall 60% reduction in GHG emissions by 2010.

B. Research Questions

- Need to know when particular technologies are sufficiently far advanced to warrant government initiatives to support market entry (perhaps wind?) as distinct from the longer term support of R&D (perhaps solar, perhaps followed by hydrogen?). Before technologies compete for the consumer dollar, they compete for the R&D dollar; some decision is inevitable. Is there enough information now to warrant going to the government to seek funding on the scale of the Manhattan project, either for research or for market penetration initiatives, for particular technological pathways? Probably not. <Or maybe, thinking of an international setting, the model should be the Marshall Plan?> How might a strategic agenda dealing with such issues be developed?
- Review the general literature on economic instruments and the relative effectiveness of p vs. q measures, and apply this to the specific case of energy systems and carbon-reducing measures.
- Revisit the vast literature on the Carbon Tax, in particular the initial distribution problems associated with the cap and trade approach to creating a new market rather than tinkering with a price; (it is harder to change a cap than a price; is there a need for international cooperation to be workable?). Note that the higher price of oil is a form of (inconsistently distributed and invisible) carbon tax; what can be learned from revealed behaviour in recent history? Carry through the analysis of measures to implement a revenue neutral reduction of the GST replaced by a carbon tax, with full exploration of the distributional consequences (if this has not already been done, it is feasible in collaboration with Statistics Canada).
- Design program of ecological fiscal reform in general. How to move toward a coherent, integrated program? Need to know specifically whether talking about low carbon in general, or hydrogen in particular.
- What would an integrated program involving enhanced investment in R&D coupled with supportive procurement policy, tax credits and demonstration projects look like? How could such a strategy be developed to the extent that it has effects comparable to the programs of support to hydrocarbon exploration and tar sands development over the last three decades?
- Pursuing the Madisonian heritage to the South, what would be necessary to undertake many small-scale initiatives as experiments (but note that fixed regulatory burden overwhelms/precludes small scale initiatives);
- Would existing venture capital facilities be sufficient to support a portfolio of such small-scale initiatives, or would some purpose-built public facility be needed?
- Examine regulatory structures and program implementation in detail.
- Develop sociological/anthropological case studies (in an interdisciplinary fashion involving also researchers with a background in natural sciences and engineering) to explore the determinants of public acceptance of technological innovations, and to explain the different degrees of fear or resistance associated with fuel cells, for example, and cell phones, by contrast.

5. Local governments and local applications, demonstration projects; confronting NIMBY

A. Action Items

- Promote conservation through initiatives like the Netherlands experiments or the SDRI GHG personal calculator, enabling people to get a sense of the implications of their personal life-styles and the possible consequences of change; develop facilities for personalized communication to inform people of their personal success in attempting to reduce electricity or water consumption (or other material inputs?)
- Recognize that 75% of energy consumption is directly related to cities; organize a project through the FCM to develop a coalition of mayors directly interested in the introduction of fuel cell technologies (in large plants, trucking,…?) as offering potential solutions to the unique circumstances of congested urban environments; promote public acceptance by positioning hydrogen as an evolutionary facilitating technology, not a disruptive transformative revolution.
- Promote university-industry partnerships in demonstration projects and market penetration initiatives.

B. Research Questions

- Recognize the crucial relationship of land use traditions and spatial cultures in shaping a possible transition toward more efficient energy systems and sustainability in general. Pursue the extensive work on urban design and the built environment to integrate this with the dynamics of technological development and transition.
- Examine specifically the means to use new technologies to assure mobility and distribution capacity in a networked but heavily urbanized society. Explore overall spatial logistics strategies.
- Explore the regulatory flexibility necessary to permit demonstration projects and develop a proposed agenda for regulatory reform to accommodate.

6. Citizen engagement, legitimate decision processes; confronting NIMTOF

A. Action Items

- Establish procedures to assure much broader involvement in risk assessment, management; create mechanisms to develop the initial framing of issues and characterizations of risk through inclusive engagement;
- Negative attitudes toward ‘new’ risks are very hard to disperse; a successful transition path will demand a budget to support exploration of human dimensions and public engagement comparable to that supporting the R&D program itself.
- Develop criteria for inclusive decision processes, promote acceptance of adverse outcomes through recognition of legitimate processes; address the question of who ultimately has the responsibility/right to take decisions when consensus cannot be obtained or who has the mandate to dictate the 50-year path.

- Reform the decision processes determining the incremental allocation of the marginal government dollars, recognizing that hydrogen-related research competes with all other claims on research dollars.
- Develop a program of public involvement around the philosophical and ethical issues involved in choice of a technological pathway, particularly the issues of intra-generational fairness and intergenerational equity.

B. Research Questions

- Examine barriers to the effective flow of science in policy, recognizing that the public is not sufficiently aware of issues to be able to press politicians appropriately; explore in particular the challenge arising from the fact (?) that the public prefers to get its science from media, not scientists.
- Review the literature exploring what kind of exchange, evidence, can be persuasive with politicians who must have evidence to justify decisions, and relate this literature to the social challenges of realizing preferred technological pathways.
- Explore the particular problem of incompatible timescales associated with research, technological transition, venture capital criteria, imperatives of commercialization as contrasted with public issue-awareness cycles, institutional reform cycles, bureaucratic decision cycles and political-electoral cycles;
- If catastrophes help to move governments to address these issues, how can current experience be enlisted to illuminate current choices?
- Undertake a survey of the vast literature on adaptation options in order to bring it more directly into assessment of options for adoption of hydrogen-related technologies.
- Address the adaptation challenge more effectively.
- Bring comprehensive footprint analysis into public discussion; assist people to recognize their responsibilities, the implications of their current action. (This might suggest an initiative to bring the hydrogen technology choices into backcasting models such as the SDRI QUEST model or similar models at a larger or smaller scale.)
- Examine the role of media in communication generally, and with respect to public consultation or deliberation exercises in particular. (Document a recommendation to sack the political advisors who are reading the media as revealing public opinion?)
- Again, do not forget the strong coupling of regional, national and global activity, through research networking, partnerships, trade, and intellectual property and through economic and community development.

III. 2005 Workshop General Themes

It seems clear that in the discussion at the exploratory workshop most people would urge attention to the broader discussion around the sub-title of the meeting (paths to a low-carbon society) rather than the more focused title (hydrogen and governance); indeed there were suggestions that the invitation to a meeting under that title might be considered false advertising in light of what was actually delivered in the workshop itself. Certainly some doubts were expressed about the extent or timing of massive reliance on

hydrogen itself as the central feature of a move to a low-carbon society (at least in the next few coming decades).

One evident consensus conclusion, indeed, seems to be that of course we are not talking about any single solution (at least through a very long transition period) to reducing carbon content and carbon-related emissions, but rather about an extensive portfolio of distinct technological options, with the composition evolving. Where we will finish a century from now may or may not be clear, but perhaps that does not matter so much for the decisions to be taken now. (On the other hand, it was also argued at the meeting that some overall vision is necessary to give orientation and suggest an end in mind to guide appropriate choices in the vast number of decisions to be encountered in a transition to new energy systems.)

But what does seem clear is that we have to ask explicitly what part of the portfolio of low carbon technologies might or should hydrogen-based technologies occupy, not take the presence of the hydrogen components for granted. The share of the portfolio will no doubt emerge over a long period. Nobody expects them to become the whole solution, and nobody expects it to play only an insignificant role.

So what might we be able to say about the process of social transition to the hydrogen economy elements of a low-carbon society?

First, **several drivers** forcing efforts to move to a low carbon society were mentioned. Many of these were identified by Ged McLean in his opening keynote address.

- Overarching all, the need to reduce GHG emissions (by reducing the use of fossil fuels) because of the threat of climate change driven by increasing atmospheric concentrations of GHG;
- The need to address threats to health from tropospheric ozone, particulates, and other air quality problems;
- The potentially very serious threat to human and global security arising from the projection of national force abroad in order to secure hydrocarbon energy supplies for domestic use;
- Unacceptable distributional consequences arising the inequitable burdens associated with rising prices as demand for (hydrocarbon) energy increasingly outstrips supply potential;
- The increasing concern for environmental quality (respecting rights of nature) or sustainability more generally (however interpreted), possibly linked particularly with concerns for water issues;
- Ambition to create a competitive Canadian export industry leading technology transfer worldwide (including export of expertise based on advanced intellectual property).

Second, there was a hint of a **hierarchy of governance responsibilities** emerging:

- Much, maybe most, of the decisions that need to be taken will be taken by individual producers developing choices to offer consumers, and consumers deciding on how to take up those choices, based on the value propositions offered,

with no need to pay any more attention to the technologies embedded under those choices than is presently paid to the role of electrons in the choice of electrical appliances. Market dynamics can be left to rule as various hydrogen-based products and other related products find niches in which they can be viable and in which consumer recognition and acceptance can be built. (We cannot predict what services will ultimately be taken up, or how they will be offered, nor how the energy intermediaries/carriers/currencies will be produced, but we can perhaps see the need for some features these energy currencies will need to have if the overall energy system is indeed to support a low carbon society.)

- But the market also needs to be corrected in order to assure a more level playing field; governments may need to deploy the whole range of economic instruments to offset existing distortions and failures in the market. These instruments may start with taxes (positive or negative) or targeted expenditures; creation of new markets through regulatory caps and trading; ecological fiscal reform more generally; hydrogen-friendly regulations; or more general technology forcing regulations expressing social targets. Federal government energy policy and program spending at the moment is overwhelmingly focused on hydrocarbons, not hydrogen-based technologies or renewable energy; this imbalance ultimately will need to be corrected.
- But citizens will not wish governments to rest with fiscal instruments, or more general economic instruments alone; governments must consider social returns on investment, not simply commercial viability; there will need to be active leadership based on the criteria and targets emerging from a more effective social debate. Some of that leadership may need to be directed to very broad concerns such as the evolution of a culture promoting more appropriate land use and spatial patterns in a rapidly urbanizing world; economic instruments can address the questions of commercialization where products are known; they cannot address strategies for research into unknown opportunities.
- It is not necessary to be passive about the emergence of technological opportunities and choice of technological pathways; societies should intervene in the direction of active discretionary choice about acceptable technologies; governments have an obligation to open institutional opportunities for inclusive, interactive technology assessment in the broadest social terms, and to support processes of active choice around the development and selection of technological opportunities.
- The classic problem of **path dependency** hangs over all; how can all the above decisions be taken properly from moment to moment while somehow holding open opportunities for adaptive responses in the face of new knowledge and surprise, to avoid foreclosing options sooner than necessary?

Third, if we take the goal of a move to low carbon, or carbon-neutral, energy sources as given, there seems to be more than a hint of a **sequencing** in the likely (or desirable) strategies driving the technological evolution.

- The first step, already in our hands, with well-known opportunities in the instruments accessible, is demand management. There is low hanging fruit to be plucked, and it might carry us a considerable way;

- A further major step, also within current research with well understood technological opportunities, is to force more rapid reduction in carbon intensity in the energy systems or economy as a whole, through energy efficiency targets, through reduced material inputs and improved industrial ecology;
- Carbon management, through sequestration and storage, or with re-use of valuable CO_2, is already technologically feasible and could be commercially attractive in the relatively near term, opening up opportunities to reduce the carbon content in electricity production, extending the life of clean(er) hydrocarbons and coal as energy sources;
- Development of renewable sources of energy to produce both hydrogen and electricity can proceed in parallel;
- All of this buys the time to let the basic theoretical and physical work on new technologies and materials for hydrogen production and storage, or fuel cell evolution, reveal the technological opportunities and offer up the choices in the normal way of the market; with current understandings, the first places in which one might expect to see widespread commercially viable applications of fuel cells might be in heavy transport—ships, trains, trucks—and large stationary plants, with automotive to come later.
- [But the warning is mentioned: hydrocarbon fuels represent an existing stock of fuel needing only to be extracted, offering very high net energy content; the move off oil and coal demands the technology to realize sufficient energy from production processes that offer very low net energy relative to the simple extraction from the existing already produced natural stock. Do we have the technological, industrial and social structures that could survive such a transition? Is exclusive reliance on renewables incompatible with continued (material) economic growth? Are capitalism and communism both incompatible with sustainability?]
- And again the problem of path dependency has to be recognized.
- One simple government policy initiative might be simply to stop putting massive new money into new initiatives and new construction that fly in the face of all the declarations of current intent to pursue sustainability, at least in part, through a reduction in greenhouse gas emissions.

Fourth, and finally, the **international dimension** was identified as one demanding much greater emphasis. Not just because the challenges to be faced are indeed global, and many of the governance issues are international as well, but also because Canada has opportunities to carve out an important role at global scale, the meeting returned often to international aspects of the discussion. Canada's potential contributions both to technology innovation and transfer and to related capacity-building abroad were emphasized. With respect to commitments to capacity-building it was argued that transfer of policy learning—appreciation of the lessons to be gained from Canadian experience with challenges of policy-making in a very long-term and uncertain setting as well as social and governance challenges associated with more inclusive and participatory decision-making processes—was as important as sharing and transfer of scientific and technological understanding and expertise.

I n the other direction, greater investment by Canada in the learning to be derived from international collaboration and participation in science and technology initiatives, and the domestic capacity to draw on the growing body of knowledge and experience elsewhere in the world was also urged.

IV. Cross-Cutting Institutional Activity

1. Throughout all of these observations runs the emphasis on **knowledge mobilization**: dissemination, research networks, diffusion through post-secondary education, schools curriculum reform, media relations, science writing…It is not just that Fred and Martha have a right to better information and greater understanding, there is also the need to build the platform for reform (think of social movements such as those around women's rights, MADD, smoking, maybe now childhood obesity…)

2. And underlying all that is the challenge of **open access documentation, archiving, and topic specific repository initiatives… ,** particularly with respect to concerns about audit and accountability, due diligence within public policy processes relating to large energy systems, and institutional assurances of adequate opportunity for public participation on the basis of access to relevant knowledge. In this connection, development of an institutional framework for computer support of deliberative processes relating to decisions on energy systems and new technologies through purpose-built knowledge repositories, databases and scenario-generation, simulation and visualization capabilities should be explored.

3. And finally, the need to develop **processes of social choice** that can support public policy as adaptive management, promoting decisions that avoid as far as possible prematurely closing of technological or social options, and resist so far as possible the irreversibilities arising from path dependence. It is essential to recognize that technological innovation is unlikely to offer a 'technological fix' of sufficient scope to enable even Canada, with its extraordinary resource wealth and opportunities, to evade wrenching social decisions.

V CONCLUSION

As might have been predicted, workshop participants concluded that discussion, even though excessively general and inadequately focused, had been fruitful, and that follow-up and future workshops would be useful. Emphasis was placed on developing and sustaining a **core policy network** to pursue this discussion of governance challenges; creating and maintaining a relevant repository and portal, and an **'evergreen' background briefing book** as a starting point and foundation for further meetings and discussion; and, most significantly, developing a 'second-track' international approach to complement the domestic policy discussions based on drawing lessons from the rest of the world with a **parallel track working with participants and institutions in the developing world** on developing and documenting shared learning as to the development of technology and policy capacity along with effective institutions of governance.

Appendix A: Some Illustrative Canadian Energy Programs

1. Federal Initiatives

Sustainable Cities Initiative (SCI)

SCI was established by the Government of Canada in 1999 following a recommendation by the National Round Table on the Environment and the Economy (NRTEE). The project, in which SCI partners with 16 cities worldwide, assists cities in obtaining their goals for sustainable development and quality of life. Areas of focus include clean water, waste management, clean energy, transportation, housing, capacity-building, urban planning, telecommunications, urban infrastructure projects and port development. SCI is a working example of a partnership between government, non-governmental organizations and the private sector, comprising over 1500 representatives. Partner cities are selected through consultation with such organizations as Industry Canada, the Department of Foreign Affairs and International Trade and the Canadian International Development Agency.

Hydrogen Early Adopters Program (h2EA)

Designed to demonstrate new hydrogen technology concepts, h2EA was launched in October 2003 through Industry Canada's Technology Partnerships Canada (TPC) – being replaced by the Transformative Technologies Program (TTP). Intentions are for h2EA to initiate efforts for the demonstration of new concepts such as 'hydrogen highways' and 'hydrogen villages'. The program's stated objectives are listed as: increased public, consumer and investor awareness and acceptance of hydrogen capability; integration of hydrogen and hydrogen-compatible technologies; development of hydrogen infrastructures; development of skills and supply chain in the hydrogen industry; development of codes and standards for the hydrogen industry; and increased performance, reliability, durability and economical viability of hydrogen and hydrogen-compatible technologies. h2EA program goals include the accelerated acceptance of hydrogen technologies and hydrogen-compatible technologies; world-class talent is attracted and retained; and domestic and foreign investments in Canada are attracted.

Canadian Green House Gas Challenge Registry – Environmental Supply Chain Management (ESCM) Pilot Project

ESCM is a means to identify and reduce GHG emissions in small and medium sized enterprises (SME). It was calculated that SME contribute 43.7% of the Canadian manufacturing industry's total GHG emissions. Since SME are usually suppliers to larger companies, ESCM has recommended reaching SMEs in order to raise awareness and provide the technical tools to reduce emissions. ESCM is a 5 year pilot program that began in May 2001. It is managed by the Canadian Standards Association (CSA) and is funded by Industry Canada, Alberta's Climate Change Central and host companies taking part: Alberta-Pacific Forest Industries Inc., Shell Canada Limited and Suncor Energy Inc.

2. Provincial Programs

British Columbia's Energy Plan

The plan, released in 2002, proposes means of achieving a clean, reliable energy future in the province of British Columbia. It outlines the provincial government's goals for promoting clean and renewable alternative energy sources and plan to aid the growth of the technological industry. The emphasis is placed on clean electricity sources, conservation and energy efficiency and on the support of the development of cleaner power sources, for example wind, wave, solar, micro-hydro and fuel cell power. The provincial government indicates its support of fuel cell projects, including the Vancouver Fuel Cell Vehicle Program (VFCVP) and the projected Hydrogen Highway. The Energy Plan lists incentives for efficient energy usage and research for both BC residents and businesses. These include: PST relief for alternative fuel cell vehicles, residential heating energy efficiency incentives, fuel tax exemptions (for biodiesel fuel) and provincial tax credits for scientific research and experimental development.

Task Force on Alternative Energy and Power Technology

The government of British Columbia task force on alternative energy and power technology published a report stating their objectives in April 2005. It is a ten year plan created to provide advice to government on how to research and implement an alternative energy strategy. As a plan to also expand BC's economy, the report projects a creation of government and industry jobs that supply sustainable power solutions and increased income (from export revenue) in addition to more jobs through power technology solutions. The stated goal of the task force is for the province to be able to access clean, secure, reliable and reasonably priced energy over the long-term, through the promotion of sustainable urban transportation and the application of fuel cells and hydrogen technology. The proposition is in place for the formation of a regulatory framework for land use to avoid the disconnected approval processes utilized in the past. To successfully employ sustainable urban practices, the government and the private sector must work together; the report thus seeks joint participation amongst industry, utilities, universities, communities, First Nations, non-governmental organizations and others.

Vancouver Fuel Cell Vehicle Program (VFCVP)

The objective of the VFCVP is to test fuel cell vehicles and hydrogen refueling stations in a real-world, daily setting in order to more effectively evaluate their performance. The program is intended to span three years of demonstrations with a total of five vehicles running in Vancouver. It is hoped that the VFCVP will facilitate the development of international codes and standards, as well as other activities critical to preparing the market, provincially, nationally and internationally, for a clean-energy future. The VFCVP involves many private sector groups and various levels of government, including BC Hydro, BC Transit, Ballard Power Systems, the City of Vancouver, Fuel Cells Canada, the National research Council, Natural Resources Canada and the government of British Columbia. This program is one of a number of hydrogen related programs targeted for implementation before the upcoming 2010 Olympic and Paralympic Games.

3. Canadian University Research Centres/Institutions

The Institute for Integrated Energy Systems (IESVic)

At the University of Victoria, researchers and students with IESVic conduct research on potential future paths for sustainable energy systems. The development of new technologies and perspectives towards clean energy alternatives and methods for overcoming barriers to achieving these goals are the focus of IESVic. Specific areas of expertise include fuel cells, cryofuels, energy systems analysis and energy policy development.

The Hydrogen Research Institute (HRI)

HRI is a research centre at the Université du Québec à Trois-Rivières. Working under the assumption that hydrogen will play an important role as a future energy carrier, HRI strives to address challenges facing government regarding the environmental impact of new energy technologies. Researcher and student work is focused on four main areas: the storage, safety and uses of hydrogen and the Centre for inspection with ultrasonics (CIUS).

The Institute for Sustainable Energy, Environment and Economy (ISEEE)

ISEEE at the University of Calgary provides leadership and coordination for the development and implementation of local energy initiatives. ISEEE also serves as an interface between all levels of research groups and sponsors in the domains of energy, environment and the economy. Focus is on the multidisciplinary approach, innovation and education to ensure secure, sustainable future energy sources and a strong economy.

Appendix B: Public Energy Awareness in the EU and the US

The preceding Appendix represents only a selection of ongoing federal, provincial and university programs in the field of sustainable energy and hydrogen energy research. Before undertaking the aforementioned potentially long, laborious and skeptic-ridden transition to a hydrogen economy, efforts must be made to inform and involve civil society. Campaigns of various forms have attempted just that in both the European and Union and the United States.

1. The European Union

Sustainable Energy Europe 2005-2008

This initiative under the European Commission was designed to help contribute to the EU's energy policy targets. Its listed objectives are to raise the awareness of decision-makers, spread best-practice, ensure public understanding and support, and to stimulate private investment in sustainable energy technologies. The campaign's aim is to support and promote actions in:

Communities – municipal activity is close enough to reach key local actors and consumers and to ensure their involvement in the formation of a vision for a sustainable community;

Transport – biofuels for transport; offer Member States the possibility of applying for a tax reduction to support the production and use of biofuels; work in the development of alternative transport through the use of fuel cells, hydrogen and hybrid vehicles;

Buildings – energy performance certified buildings; construction of "very low energy" houses;
Lighting systems and appliances – promotion of low-energy lighting and appliances;
Cooperation with developing countries; promotion and communication.

Through the development of a European-wide network, small and medium sized businesses will have the opportunity to cooperate and learn from the experiences of others in the industrial market. Enterprises, both public and private, can become "partners" of Sustainable Energy Europe and be provided with assistance in increasing awareness of their goals and achievements.

The campaign website, http://www.sustenergy.org/tpl/index.cfm, provides information on the initiative and its activities, including a specifically designated "citizen area", where European citizens can "find out how to become involved". The public can be informed on "Sustainable Energy Days/Weeks" and open-door days with organizations partnered with the campaign. School-aged educational activities are suggested, as are methods for daily energy conservation. The public is encouraged to become actively involved in conferences and workshops affiliated with Sustainable Energy Europe, and a list of such upcoming events is provided, along with locations and contact information.

Eurobarometer (2002)

Under the Public Opinion Analysis sector of the European Commission, the 2002 Eurobarometer served to analyze the attitudes of citizens of the EU on energy and energy technology issues. This study polled 16,000 individuals over the age of 15 and was conducted amongst the 15 Member States. The results from such studies are intended to be consulted for the preparation of texts, in decision making and for the evaluation of completed work.
An overview of the results and conclusions drawn from this report show that:

- the level of education and social background influenced the awareness of and responses to environmental issues;
- there is a vague idea overall of energy consumption levels, but most see energy use as increasing;
- most would like to have information on concrete issues, such as energy saving, and on alternative forms of energy;
- more environmental protection research, renewable energy and cleaner transport is wanted;
- 85% were unaware of EU energy research and development;
- the main sources of energy information: television – 80%, newspaper – 47%, radio – 27%, internet – 10%;
- 54% want to be consulted where "local" plans are concerned;
- attitudes varied according to country of residence, socio-demographic background and ideological leanings

HySociety

The main initiative of HySociety, a two year program funded by the EU that ended in March 2005, was to support the introduction of a European hydrogen-based economy.

It's focus was on the non-technical barriers confronting hydrogen energy, more specifically on questions of public perception of hydrogen energy and the potential reactions of the public to its introduction to society. The objectives of HySociety were listed as follows:

1. To review the state-of-the-art in hydrogen technologies and identify non-technical barriers to the hydrogen society.
2. To analyze plausible hydrogen scenarios and assess the economic, social and environmental impacts of the introduction of hydrogen into European society.
3. To provide European policy-makers with an Action Plan for the introduction of hydrogen in European society.
4. To foster broad public awareness and debate as to the opportunities and challenges of the hydrogen society, stimulating the dialogue with all interest groups.

With its focus on the increasing awareness, education and acceptance of hydrogen by the European public as well as the prompting of discussion between all groups, it is intended that the results of HySociety will ultimately contribute to the preparation of policies, codes and standards for hydrogen issues in the European community.

2. The United States

National Hydrogen Energy Roadmap

The National Hydrogen Energy Roadmap is drawn from a Department of Energy 2002 workshop. Its intention was to investigate the potential role of hydrogen in solving the energy security, diversity and environmental needs of the United States and to coordinate the efforts of public, private, governmental and nongovernmental groups in the future application of hydrogen energy. Suggestions were made for careful consideration in various areas of hydrogen design and implementation: production, delivery, storage, conversion and application. It was also noted that education and outreach are critical steps in ensuring the awareness of consumers, students, educators, public policy makers, NGOs, the R&D community, industry, media, multilateral institutions and professional and trade associations. Consumers are generally unaware of hydrogen energy as an alternative. The value of switching from fossil fuels to hydrogen must be evidenced through ongoing education, demonstrations, online hydrogen databases, policy initiatives and marketing material. Public safety concerns must be addressed and the safety of hydrogen as an energy carrier must be stressed.

RAND Forum on Hydrogen Technology and Policy

The RAND Corporation held a forum late in 2004 with the intention of facilitating discussion on topics relating to improving decision making with regards to and investments in hydrogen energy. The potential benefits associated with hydrogen were debated, as were the steps involved with moving forward, the risks of inaction and the hurdles with the implementation of hydrogen as an energy carrier. In addition to policy and corporate risk barriers, public-perception barriers were addressed.

The perception of hydrogen energy by the public will undeniably play a determining role in whether hydrogen is developed as an alternative energy source and the speed of such a

transition (i.e., nuclear energy and public apprehension). Forum participants discussed the following issues concerning the public and hydrogen energy:

- The potentials of hydrogen are difficult to explain as there are many means of production and the product is not visible;
- Semantics are a problem – hydrogen is an energy carrier, not a fuel;
- Hydrogen benefits are numerous and complex, again complicating public explanations;
- From the public's point of view, the incoming hydrogen technology must be better than what it's replacing in order them to get on board.

U.S. Department of Energy; Energy Efficiency and Renewable Energy – Hydrogen, Fuel Cells & Infrastructure Technologies Program

The main objectives of the Hydrogen, Fuel Cells & Infrastructure and Technologies Program include:

- Overcoming technical barriers through research and development of hydrogen production, delivery, and storage technologies, as well as fuel cell technologies for transportation, distributed stationary power, and portable power applications;
- Addressing safety concerns and developing model codes and standards;
- Validating and demonstrating the use of hydrogen energy and fuel cells in real-world conditions;
- Educating stakeholders, public.

In order to address main public concerns regarding hydrogen energy a handbook of "Best Management Practices for Safety" is intended for publication by 2010. Its goal would be to ensure safety in hydrogen related actions and activities.

The program also intends to launch a public education campaign about the hydrogen economy and fuel cells by 2010. The campaign is directed at teachers, students, state and local government representatives, safety and code officials, commercial users. The website, http://www.eere.energy.gov/hydrogenandfuelcells/education/, provides information and resources to the interested public on such topics as the functioning and logistics of hydrogen and fuel cells, higher education and career opportunities in the field, student and teacher competitions, possible lesson plans for educators, and links to other informative sites in the internet.

Appendix C: Session Papers

Links to session 1 participant papers:

Challenges to a Sustainable Energy Future in a Climate Change Setting
Chris Green, Soham Baksi, Maryam Dilmaghani, McGill University
http://www.globalcentres.org/publicationfiles/CGreen.pdf

Rethinking Hydrogen Cars
David W. Keith, University of Calgary, and Alexander E. Farrell, University of California Berkeley
http://www.globalcentres.org/publicationfiles/Keith.pdf

Why Hydrogen? Can Anything Better Come Along?
David Sanborn Scott, IESVic
http://www.globalcentres.org/publicationfiles/DSScott.pdf

Hydrogen in a Sustainable Energy's Future: Design Imperatives for Deliberate Sustainability
Stephanie Cairns, Wrangellia Consulting
http://www.globalcentres.org/publicationfiles/SCairns.pdf

Links to session 2 participant papers:
Thoughts on Hydrogen and Governance
Frano Barbir, Associate Director for Science and Technology, United Nations Industrial Development Organization
http://www.globalcentres.org/publicationfiles/FBarbir.pdf

Briefing on the state of the art of Hydrogen Technology
Richard Chahine, Hydrogen Research Institute, UQTR
http://www.globalcentres.org/publicationfiles/RChahine.pdf

Links to session 3 participant papers:
Political Economy and the Hydrogen Revolution
David G. Victor, Thomas C. Heller, Nadeja M. Victor
http://www.globalcentres.org/publicationfiles/Victor_econ_H2.pdf

The Politics of a Hydrogen Economy: Networks and the Role for Industry, Government, NGOs, and Citizens
Dianne Cunningham, Director, Lawrence National Centre for Policy and Management, Richard Ivey School of Business, University of Western Ontario
http://www.globalcentres.org/publicationfiles/DianneCunninghamWorkshop.pdf

Links to session 4 participant papers:
What are the barriers to translating science into policy?
Hadi Dowlatabadi, University of British Columbia, SDRI
http://www.globalcentres.org/publicationfiles/HDowlatabadi.pdf

Translating Science into Policy: Notes for Discussion
William Leiss, University of Ottawa
http://www.globalcentres.org/publicationfiles/WLeiss.pdf

Some Preliminary Issues for Thinking About Risk and Hydrogen: the relations between 'science' and 'policy"
Brian Wynne, Lancaster University
http://www.globalcentres.org/publicationfiles/BW%20UVic%20Hydrogen%20draft.pdf

Links to session 5 participant papers:

Regulated Monopolies for Sustainable Energy Solutions?
Denis Connor, QuestAir Technologies
http://www.globalcentres.org/publicationfiles/DConnor.pdf

Some notes on the roles of government, industry, civil society and universities to enable a sustainable energy future
Ned Djilali, IESVic, University of Victoria
http://www.globalcentres.org/publicationfiles/Ned%20Djilali.pdf

What roles should government, industry, civil society and universities play to enable a sustainable energy future?
Elizabeth May, Sierra Club of Canada
http://www.globalcentres.org/publicationfiles/EMay.pdf

What should government do to advance the hydrogen economy?
Harry Swain, CFGS
http://www.globalcentres.org/publicationfiles/HSwain.pdf

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