A New Framework:
Post-Kyoto Energy & Environmental Security

White Paper / Research Agenda
Energy & Environmental Security Initiative (EESI)
University of Colorado School of Law

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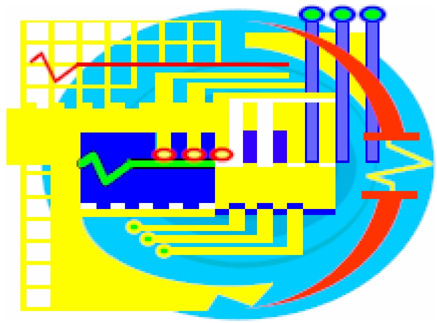
A NEW FRAMEWORK:



POST-KYOTO ENERGY & ENVIRONMENTAL SECURITY

Energy & Environmental Security Initiative (EESI) Home Page: http://www.colorado.edu/law/eesi

CONTENTS

TABLE OF ACRONYMS

CBDR	Common But Differentiated Responsibility
DOE	U.S. Department of Energy
DSP	U.S. Dept. of Energy Draft Strategic Plan
ECT	Energy Charter Treaty of 1994
EESI	Energy and Environmental Security Initiative
GHG	Greenhouse Gas
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IEP	1974 Agreement on an International Energy Program
IPCC	Intergovernmental Panel on Climate Change
IPHE	International Partnership for the Hydrogen Economy
OECD	Organization for Economic Cooperation and Development
PEERA	1998 Protocol on Energy Efficiency and Related Environmental Aspects
R&D	Research and Development
S&T	Science and Technology
SD	Sustainable Development
SSP	Solar Space Power
T&I	Trade and Investment
UNCED	1992 United Nations Conference on Environment and Development
UNFCCC	1992 United Nations Framework Convention on Climate Change
WPT	Wireless Power Transmission
WSSD	2002 World Summit on Sustainable Development

I. THE OBJECTIVE

This Proposal/ Research Agenda (EESI Proposal) of the Energy & Environmental Security Initiative of the University of Colorado School of Law (EESI) is a preliminary attempt, and an invitation, to begin construction of a knowledge base and analytical compass that together will facilitate the development and drafting of international energy instruments. This initiative is designed to address the energy and environmental insecurity confronting the world. A conceptualized research framework is depicted at page 18.

Traditionally, national security has been associated with armed aggression and the ability to thwart military invasions or subversion. More contemporary concepts of security include critical threats to vital national and international support systems such as the economy, energy and the environment. In this context, the increasing reliance on hydrocarbons has created energy, environmental and economic insecurity. This EESI Proposal is a response to that threat.

The references to "instruments" in this EESI Proposal are to a genus that could include a variety of multilateral and bilateral agreements, pacts, treaties, protocols and conventions dealing *inter alia* with science and technology (S&T), trade and investment (T&I), research and development (R&D), technology transfer and sustainable development. As currently envisioned, the principal objective of these instruments will be to facilitate the development of primary sources of energy—i.e., energy in its naturally occurring form—as well as energy conversion, transmission and end-use distribution.[1]

The present EESI Proposal seeks to advance this objective by providing decision-makers with a comprehensive scientific, engineering, economic and socio-political knowledge base and policy compass that will illuminate pathways toward an integrated approach to the development and deployment of renewable energy through international instruments.

The EESI Proposal presented here builds upon research frameworks already delineated,[2] which are fostering the development of low greenhouse gas (GHG) global energy systems primarily by facilitating technology research. EESI plans to complement this process by introducing a comprehensive multi-disciplinary, systems based policy domain that integrates hitherto fragmentary scientific, engineering and policy responses.

The primary objective of such a policy domain will be to explore ways of institutionalizing and deploying new generation technologies being developed by other more scientifically driven and technologically grounded initiatives. While EESI seeks to advance the negotiation of international accords necessary to meet future energy needs, it does not presume to legislate the scope, structure, specific subject matter, final terms or norms of the proposed new energy instruments. Instead, this EESI Proposal is intended as a starting point from which to begin the arduous interdisciplinary and collaborative work necessary to negotiate instruments ranging from S&T agreements to T&I treaties to more ambitious regional treaties and overarching global conventions or protocols.

II. <u>RATIONALE</u>

The manner and extent to which increasing global energy demand can be met within the framework of sustainable development (SD) presents the greatest global environmental challenge of the 21st century. The case for new energy accords is premised upon five widely recognized phenomena. First, according to some estimates today's current primary global power consumption of about 12 TW will reach 30 TW by 2040.[3] Other forecasts suggest total global energy consumption will expand by 58 percent between 2001 and 2025.[4] A significant and troubling part of this projected increase in energy demand will occur in developing countries that rely primarily upon the combustion of hydrocarbons such as coal to produce the electricity necessary to meet their energy demands.[5]

Second, the environmental consequences of using fossil fuels or hydrocarbons to produce energy are formidable and fearsome. Apart from the possibility that hydrocarbons are greenhouse gases that may cause anthropogenic global warming, the entire hydrocarbon energy cycle of production, mining, transportation, refinement, use, and emissions are fraught with daunting environmental and public health problems. The environmental and public health effects and impacts of acid rain, heavy metals, urban smog—created by the mining and burning of fossil fuels—can be very damaging to both developing and developed countries.

Third, oil and gas are finite and non-renewable natural resources. Oil and gas are not as abundantly available as coal. Moreover, because the demand for oil and gas far exceeds the supply of those countries that rely most heavily upon them, these countries are compelled to import oil and gas from politically volatile parts of the world.[6] This phenomenon exposes many developed countries to shortages of vital energy sources. Indeed, energy shortages are perceived as posing a threat to the national security of the United States, the European Union, Japan, and other developed nations. According to the present U.S. administration, this country faces the most serious energy shortage since the oil embargoes of the 1970s.[7] Estimates indicate that over the next 20 years, U.S. oil consumption will increase by 33 percent, natural gas consumption by as much as 50 percent, and demand for electricity will rise by 50 percent.[8] The implications of such increases in energy consumption are ominous.

Fourth, even appreciating the 1974 Agreement on an International Energy Program (IEP), and the 1992 United Nations Framework Convention on Climate Change (UNFCCC), and perhaps the Energy Charter Treaty of 1994 (ECT), all three of which are referred to in the next section, the global response to the energy crisis has been unsatisfactory. In this context, the Kyoto Protocol of 1997 responds to the danger of global warming caused by anthropogenic actions and requires reductions of carbon dioxide emissions. Unfortunately, Kyoto almost totally disregards the need to find alternative sources of energy that can supply the burgeoning energy needs of the world. Not surprisingly, even Parties to Kyoto have recognized the absence of suitable alternatives and balked at cutting down on coal. The sidelining of Kyoto has been foreshadowed by the emerging consensus among the scientific community that the reports of the Intergovernmental Panel on Climate Change (IPCC) significantly overestimated the extent and availability of alternative sources of primary energy that could fill the energy gap created by reductions in the use of coal and other hydrocarbons.[9] The recent decision of Russia to ratify Kyoto may breathe some life into it, but does not alter the fact that Kyoto fails to address the looming energy deficit by identifying and developing new sources of energy.

Fifth, the search for smart energy that is plentiful, efficient, and accessible to replace or supplement our present environmentally damaging fossil fuel sources will involve new technological developments and creative assumptive frameworks dealing, *inter alia,* with energy production, distribution, delivery, storage, conversion, end uses, and environmental protection. These technologies and assumptive frameworks need to be assessed and expressed in a manner which facilitates and secures global, national, and multinational corporate responses. EESI attempts this task.

III. LEGAL FOUNDATIONS

The task of facilitating the design and negotiation of new instruments needs to be integrated with prior international endeavors. Two are of particular importance: the IEP and the UNFCCC. The United States is a party to both these agreements.

The IEP was a response to the energy crisis of 1973–74 when the Arab oil embargo sent oil prices spiraling upward and left the major industrialized countries feeling very vulnerable. The rich industrial countries of the world, who were members of the Organization for Economic Cooperation and Development (OECD), responded with the IEP: a new international treaty aimed primarily at ensuring the adequate supplies of oil at affordable prices. The IEP created a new international organization, the International Energy Agency (IEA), as its implementing agency.

Ensuring the stability and security of oil supplies remains the primary objective of the IEA. The objective of stabilizing oil supplies is supplemented by a number of environmentally significant long term objectives pertaining to the conservation of energy, development of alternative sources of energy, and research and development of renewable energy. These environmental objectives have assumed much greater practical importance and led the IEA to create a number of Standing Groups and Working Parties dealing with different aspects of the energy environmental interface. The IEA has also facilitated a host of Implementing Agreements on a variety of renewable energy frontiers including advanced fuel cells, photovoltaic power systems, hydrogen, and wind turbine systems.

Internationally, the IEA has become the primary functional engine for facilitating renewable energy research. However, the operational significance attached by the IEA to renewable energy does not arise from legally binding obligations created by the IEP. The renewable energy aims of IEP are hortatory not mandatory, and remain secondary to its primary objectives of securing reliable oil supplies. The IEP does not contain any legally binding obligations requiring the creation, transmission and deployment of renewable energy to address today's energy and environmental insecurity. Moreover, it is essentially an organization of rich developed nations. Its membership does not include developing countries like China or India who will become the greatest consumers of fossil fuels, and emit more carbon dioxide in 2015 than the combined emissions of IEP Parties. While the IEA has sought to include some developing countries in its Implementing Agreements, such developing countries remain invitees not peers, and lack parity of status with IEP members. Consequently, new international instruments in which developing countries are primary parties and stakeholders offer better vehicles for fulfilling the work begun by the IEA. Such new instruments could more sharply clarify and define the rather vague and amorphous renewable energy mandates of the IEP, and render them more specific and enforceable.

The ECT was agreed to in 1994 with a view to establishing a legal framework to promote long term co-operation in the energy field. It came into force in 1998, and seeks to provide a non-discriminatory legal foundation for international energy cooperation and deals with investment protection, trade in energy, freedom of energy transit, and improvements in energy efficiency. It has been ratified by nearly fifty countries primarily in old and new Europe, and the now independent countries of the ex-Soviet Union. It is mainly focused on trade and investment and provides for protection of foreign investment thus ensuring a stable basis for cross border investments among countries with differing social, cultural, economic and legal backgrounds. Under its umbrella the Parties have negotiated a Protocol on Energy Efficiency and Related Environmental Aspects (PEERA) in 1998. PEERA provides a platform for the cooperation in developing energy efficiency.

While the ECT has taken a step toward global energy cooperation, it does not specifically address how to develop primary sources of renewable energy, and the parties have been unable to agree on a Protocol dealing with renewable energy or the re-engineering of infrastructure. Moreover, the United States, China, India, Japan, and Australia are not parties to the ECT. It is important to carry the momentum of the IEP and ECT toward international agreements that include developing countries like China and India that will become the largest users of hydrocarbons.

The UNFCCC is a response to global climate change, and contains a cluster of amorphous legal obligations. It has the unique distinction of having been ratified by all the countries in the world. Three interlocking mandates are of special importance: (i) stabilization of GHGs; (ii) common but differentiated responsibility (CBDR); and (iii) the right to sustainable development. First, UNFCCC requires all parties to stabilize GHG concentrations "at a level that would prevent dangerous anthropogenic interference with the climate system" [art. 2] within a time frame consistent with sustainable development. The implications of this obligation are extensive. Coal, oil, and to a lesser extent natural gas, are the primary GHGs implicated in climate change, and the obligation to stabilize GHGs requires the Parties to create or find alternative or substitute sources of energy to replace potentially dangerous hydrocarbons and facilitate sustainable development.

This obligation is accentuated by the principles of "equity" and CBDR [art. 3(1)] for protecting the climate system. Equity and CBDR require developed countries to shoulder the primary responsibility and take the lead in combating climate change. Developed countries have, therefore, accepted a duty to create and share new technologies that use and enable non-climate changing sources of primary energy.

The first two sets of obligations interlock with a third institutionalizing the right to sustainable development.[10] The assertion that the "Parties have a right to . . . promote sustainable development [and] . . . . that economic development is essential for adopting measures to address climate change" [art. 3(4)] was an affirmation of the primary theme of the 1992 United Nations Conference on Environment and Development (UNCED). The primacy of sustainable and economic development was resoundingly re-asserted at the recently concluded 2002 World Summit on Sustainable Development (WSSD).

These three legal obligations require developed countries, independent of their own energy predicament, to strive for a more diversified energy portfolio and places a duty on them to promote sustainable development in the developing world. A commitment to sustainable development (SD) requires the developed world to undertake fundamental R&D on new technologies for producing better forms of primary energy and transfer such technologies to developing countries.[11] The creation of new technologies will remove the threat of energy insecurity in developed countries, while their transfer to developing countries will promote sustainable economic and energy growth.

The major issues arising in this context pertain to the existence, availability and practicability of future sources of primary energy, and the candidate technologies that offer feasible solutions to the energy and environmental crisis, and importantly, the manner and mode in which the technology will be deployed. The canvassing of promising new directions in innovative technologies able to exploit a variety of energy sources will form a vital element of the proposed knowledge base and also help to traverse the cobbled passage from invention to commercial deployment.

IV. NEW DIRECTIONS

A. Hydrogen

Hydrogen holds promise as an ultra-clean, environmentally friendly and secure energy option for the world's energy future. Hydrogen can fuel pollution free internal combustion engines reducing auto emissions by more than 99 percent. The U.S has focused on developing hydrogen production, infrastructure, and fuel cell technologies for vehicles that could eliminate dependence on oil. Apart from transportation applications, hydrogen could have broader use as a fuel of the future through stationary power generation and portable power systems that could be used in consumer electronics.

The recent Draft Strategic Plan (DSP) of the U.S. Department of Energy (DOE) cogently argued and concluded that the challenge posed by energy insecurity should be addressed by developing technologies that foster a diverse supply of affordable and environmentally sound energy.[12] Thus, in addition to further research into alternative energy and advanced nuclear technologies, the DSP envisions developing technologies that will enhance the efficacy of exploration, development and production processes for domestic oil fields. The DSP also commits to developing new technologies for the DOE's Integrated Sequestration and Hydrogen Research Initiative. This initiative is a 10-year, $1 billion collaboration between government and industry for the purpose of designing, building and operating FutureGen—the world's first virtually zero-emission, coal-to-hydrogen power plant. FutureGen is also intended to serve as an international test facility for advanced carbon sequestration technologies.

Internationally, the U.S. envisions that the International Partnership for the Hydrogen Economy (IPHE) will foster the implementation of cooperative efforts to advance research, development, and deployment of hydrogen production, storage, transport and distribution technologies.[13] The IPHE will also enhance collaboration on fuel cell technologies, common codes and standards for hydrogen fuel utilization, and help to coordinate international efforts to develop a global Hydrogen economy. The IPHE will seek to coordinate its efforts with the IEA, as the IEA's work is an important complement to those efforts.

The creation of a Hydrogen economy faces many challenges, and prevailing uncertainties. An array of difficulties on technological, economic and infrastructural fronts could mean that the investments of today may not yield the Hydrogen economy of tomorrow. Although Hydrogen is the most abundant element in the universe it occurs primarily in compounds on earth. Thus H_2 needs to be produced from diverse primary sources including natural gas, coal, nuclear power and renewable resources—e.g., wind and solar. Today, "[p]er unit of heat generated, more CO_2 is produced by making H_2 from fossil fuel than by burning fossil fuel directly."[14] In light of the problems encountered in producing and using it, Hydrogen can emerge as the fuel of the future only if other sources of primary energy such as renewables or nuclear power, can be harnessed to produce Hydrogen more efficiently and safely.

Producing more primary energy offers a win-win solution to the energy and environmental problems of the world than one based on Hydrogen alone. Finding better sources of primary energy will enable us to replace hydrocarbons regardless of whether or not we do so through Hydrogen. Consequently, it is necessary to explore the extent and feasibility of producing or harnessing more primary sources of energy such as solar, wind, ocean thermal, geothermal, tidal power, de-carbonized coal, nuclear fission, fusion and other hybrid technologies that could replace hydrocarbons and perhaps, though not necessarily, be used to produce Hydrogen.

B. Other Sources of Primary Energy

This EESI Proposal acknowledges the promise of Hydrogen and the desirability of moving to a Hydrogen economy. However, we conclude that producing more primary energy based on renewable sources, as well as "new traditionals"—hydrocarbons stripped of their defects—offers a better transitional as well as final outcome to the energy crisis. As a transitional strategy finding new sources of energy will ease the move to a Hydrogen economy. In terms of a final outcome, new sources of energy will always be required to create Hydrogen. Consequently, the development of new sources of primary energy offers a win-win solution to the energy and environmental problems of the world by enabling us to replace hydrocarbons while simultaneously moving toward a Hydrogen economy.

V. <u>ANALYTICAL STRUCTURE</u>

The relevance and appeal of any international instrument, and the extent of its acceptance, will depend in great measure on the strength of its scientific, engineering, technological, legal, social, economic and behavioral knowledge base and underlying analysis. For example, the instruments proposed by EESI will be multidimensional entities, and each of their facets will require specific expertise and entail diverse forms of analysis. Thereafter, the varying analytical strands based on fragmented knowledge blocks dealing with science, technology, markets, and deployment will need to be integrated and configured into a sociopolitical aesthetic that lends itself to treaty making. This kind of comprehensive analysis will involve a dynamic interactive process.

The framework conceptualized as a Greek temple seen at page 19, is a preliminary attempt to provide a schematic of this process. The matters alluded to in the Doric columns of the figure will be critically evaluated by a broad spectrum of contributors and collaborators including natural and physical scientists, social scientists, engineers, economists, philosophers and lawyers. These experts will be invited to evaluate the various subjects enumerated in the three columns. Their charge, *inter alia,* will entail a dynamic continuous assessment process for analyzing and exploring the components of the three columns. The Research Profile that follows attempts to start that analytical process by offering a preliminary profile of the more important challenges confronting this venture.

VI. <u>PRELIMINARY RESEARCH PROFILE</u>

This is a preliminary work profile which given the dynamic character of this venture is subject to change. The profile will follow the contours of the conceptual schematic, and the challenges will be listed seriatim. This is not a ranking order and it is perfectly conceivable, despite their interconnections, to undertake each segment as an independent research module.

A. Treaty Review

First, EESI will undertake a cross cutting ***Treaty Review*** that will offer an overview and give perspective to the research agenda, while supplementing the legal foundations of the project. The challenges facing renewable energy are listed below, and have been addressed with varying success, in a variety of ways by the 192 countries of the world. Researching the individual responses of each country to determine how each nation responded to the suite of challenges it confronts, is a Sisyphean perhaps impossible task. A number of these problems, nonetheless, are common to many nations of the world who have recognized their inability to solve them purely by their own endeavors.

This realization has led them into cooperative international agreements addressing these issues. Such international agreements show how different countries have responded to common problems, and offers a window to their thinking. Moreover, energy treaties or agreements distil and re-state the thinking of the parties. A study of treaties thus becomes a felicitous and innovative way of garnering the world's common understanding and perception of the energy crisis, and the attendant global responses.

There are a range of international instruments dealing *inter alia* with renewable energy, R&D, T&I, and S&T, energy efficiency, energy conservation, energy transit, technology transfer and energy markets. The Treaty Review will examine all relevant energy treaties with a view to determining the scope and subject matter of future international energy instrument. Apart from the IEP and the ECT referred to in Section III, most of the other agreements are piecemeal efforts to deal with discrete questions on a case by case basis. The ***Treaty Review*** will also examine a range of related and analogous international (government to government), and transnational (private agreements crossing national boundaries), and corporate efforts addressing renewable energy, high energy physics, fusion, and space exploration to determine the most effective and efficient forms of international cooperation.

EESI researchers will analyze the information yielded by the ***Treaty Review*** with a view to developing an integrated analytical map depicting the existing overlay of engineering. geopolitical, socioeconomic, environmental and commercial responses embodied in treaties. This map of existing international responses will be superimposed upon the conceptual vision of EESI, to provide a cartography of energy challenges and responses. We will also attempt to distil objectives, principles, cooperative frameworks, institutional structures and dispute settlement mechanism that might be relevant to the creation of new more comprehensive energy instruments addressing renewable energy.

B. Foundations and Science [Column 1]

Second, The EESI Proposal will expand and explicate the meaning of existing foundational norms preventing dangerous anthropogenic GHG emissions, common but differentiated responsibility, and the right to sustainable development, and they will be juxtaposed with the needs of developing countries.

Third, any such assessment must include the possible climatic perils posed by various GHGs, the health, environmental, and agricultural impacts of hydrocarbons, along with projections regarding both the finite nature of geologic reserves of oil and gas and how long these particular hydrocarbons may last in the face of spiraling world demand. There is an abundance of scientific writing dealing with the environmental pollution caused from mining to final disposal of fossil fuels, and an even greater mass dealing with global warming and climate change. The natural, physical and atmospheric scientists on EESI will collaborate with distinguished research institutions and laboratories to synthesize and summarize such scientific findings.

C. Engineering Solutions & Markets [Column 2]

Fourth, EESI will conduct a ***Technical Review*** of engineering solutions either established or in progress, referred to in column 2 of the conceptual schematic. In addition to evaluating the feasibility of producing hydrogen through such renewable energy sources as solar, wind, ocean thermal, geothermal, tidal power and biofuels, the assessment will also canvass technologies that have the potential to facilitate an optimal Hydrogen economy transition by significantly contributing to the availability and utilization of primary energy sources. A number of the candidate technologies referred to in the diagram include: solar space power; decarbonization and sequestration of carbon dioxide from fossil fuels; nuclear fission; nuclear fusion; fission- fusion hybrids. This aspect of the study will also traverse hydrogen production, storage and transport; superconducting electric grids; energy conservation and efficiency.

For example, in examining solar space power (SSP) the ***Technical Review*** will assess the feasibility and strategic efficacy of utilizing space-based geo-engineering and wireless power transmission (WPT) to capitalize on the unique attributes of space and provide energy on Earth. Of particular importance to the geopolitics of energy is the possibility of using satellites to beam solar energy to developing equatorial countries that might otherwise rely on fossil fuels. Such a prospect also will be examined in this aspect of the project.

A comprehensive analysis of energy options conducive to the attainment of a Hydrogen economy requires examining the potential for producing hydrogen with both nuclear fission and fusion. Such an analysis must also explore technologies and techniques capable of mitigating the adverse environmental impacts of fossil fuel utilization. In this vein, the assessment will evaluate the extent to which decarbonization and carbon sequestration can effectively remediate these impacts. The assessment will also explore the potential for conservation techniques and efficiency technologies to assist in meeting the energy demands of an increasingly voracious global population.

The technical assessments, efficacy and reliability of various engineering solutions ranging from solar to Hydrogen is being undertaken by number of other research, governmental and commercial entities. EESI will review and consolidate the scientific and engineering assessments offered by these other agencies. What EESI will seek to do is to integrate and synthesize their conclusions so as to offer a one stop review of the technological and engineering achievements in the field of renewable energy.

Fifth, EESI will address the ***Market Barriers*** *(as distinct from technical hurdles)* in deploying technology and attracting investment.[15] Deployment refers to the commercial adoption, market viability, penetration and societal acceptance of renewable energy technologies. There is a cluster of renewable energy technologies such as those harnessing wind energy that are now commercially viable. Others including some of the new technologies referred to in column 2, like fusion power reactors, may take many decades to come on stream. EESI will collaborate with other research institutes to review the market barriers to the deployment of new renewable energy technologies ranging from the higher costs and financial barriers of using new technologies compared to those already in place, issues of sunk costs, information barriers, transaction costs, price distortions, capital turnover rates, market organization and regulations that make deter or delay deployment.

Sixth, EESI will address the extent to which ***Organizational & Technological Infrastructure*** could reduce the time lines from discovery to deployment that can take up to six decades. The journey from invention through demonstration projects to commercially viable technologies and services capable of market penetration can be an arduous one. Organizationally, the length of the time line from discovery to market can be shortened by the extent and efficacy of horizontal networks that weave R&D, capital, knowledge, products and talent.[16] Such an endeavor requires the active collaboration of governments, private firms, research institutions, financiers, suppliers and consumers. The DOE's Integrated Sequestration and Hydrogen Research Initiative, referred to above, may pave the way and provide a model for the sort of public and private collaboration required. There are other precedents for international collaboration offered by high energy physics, nuclear fusion and astronomy. EESI will examine these and other collaborative ventures with a view to drawing up possible road maps for better organizing the process from discovery to market deployment.

On the technological front the present hub and spoke energy transmission networks, that form the grid system, were designed for central power plants close to users. That is not the case with renewable energy which needs, in some cases, to be conveyed thousands of miles. For example, in the U.S., the winds on the planes of North Dakota could make substantial contributions to the energy needs on either U.S. coast. However the absence of necessary transmission lines and grids presently prevents the transfer of wind power from North Dakota to the Pacific or Atlantic Coast.[17]

Moreover, while cost effective photovoltaics and wind turbines may be expected to come online in the foreseeable future—and could also serve as catalysts for hydrogen production—they presently face formidable transmission problems due to their intermittent and dispersed character. It has been suggested that an advanced global electric grid is a possible alternative to conventional power distribution systems.[18] Consequently, national grid systems may need to be re-engineered. Internationally, there is no global grid system that could ensure world wide distribution of photovoltaic and wind as well as space solar power when available. EESI will examine the feasibility of re-engineering national and international grids.

D. Discovery to Deployment [Column 3]

The third column depicted in the schematic at page 19 calls for a multi-tiered analysis of the legal, sociopolitical and economic challenges of achieving a sustainable global energy future. As we have noted, any such analysis must explicitly recognize and incorporate the need for economic strategies, incentives and modalities for promoting both government and private investment in developing the science and technology necessary to making progress toward a clean energy future. This aspect of the project will also address the attendant questions of technology transfer and property rights. While the concept of sustainable development will provide the initial framework for dealing with these issues, it will be necessary to formulate a functional definition of SD insofar as it relates to energy and environmental security. The proffered definition of SD should also lend more specificity to the three interconnected foundational obligations established by the UNFCCC.

The technical and economic barriers to the deployment of renewable energy technologies are influenced by governmental decision making, and the seventh objective will be to explore ***Governmental Regulation***. In addition to the issues referred to under the heading of Market Barriers, ***Government Regulations*** dealing with economic incentives, taxes, charges, subsidies, licensing, R&D, conservation and environmental regulations could encourage or discourage renewable energy. EESI, after reviewing the work, *inter alia*, of the IEA, the ECT, and other national and international institutions and agencies, will try to identify government regulations that have been successful in encouraging market deployment of renewable energy technologies.

Although ***R&D*** policies are referred to in column 2 and subsumed under Governmental Regulations in column 3, the importance of R&D behooves that it be addressed as the eighth challenge. The required investment in R&D for the technologies referred to in column 2, especially space solar power, fission, and Hydrogen, will run into billions of dollars. Almost all energy technologies are developed and sold by corporations in the private sector. Technologies accelerated by government research such as gas turbines, commercial aircraft, spaceflight, radar, lasers, integrated circuits, satellite telecommunications, personal computers, fiber optics and cell phones took less than multi decades to move from invention to markets.[19] While there is little doubt that government sponsored basic science and technology research is vital[20] it is equally important to recognize the critical role of private capital and private research. Difficult questions persist about the extent, stage, character and form of focused government R&D expenditures and how they interface and might be synthesized with private research.

VII. REMAINING QUESTIONS

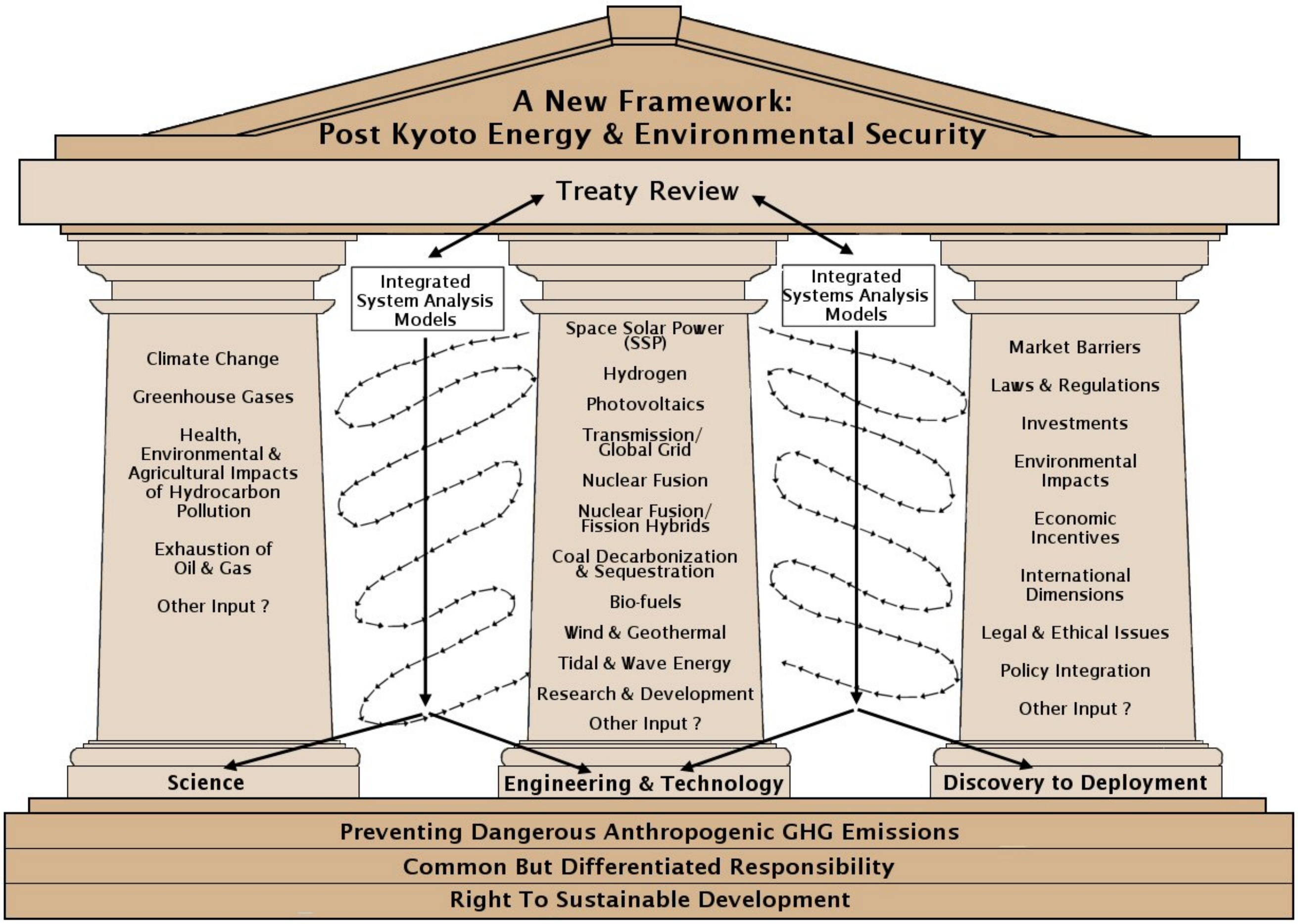
The forgoing offers a preliminary not a final assessment. The final picture will be presented after the integrated policy analysis and assessment that forms the final stages of the preliminary research profile. The final stage of the project will paint a comprehensive account of the scientific, technological, economic, engineering and socio-legal contours of potential primary energy sources that might also be used to facilitate the development of a Hydrogen economy.

A central focus of the interdisciplinary assessment at that point will be the identification and analysis of general and specific solutions to the broad array of issues and problems implicated by transition scenarios to a Hydrogen economy.[21] This focus will be pursued within an integrated and interdisciplinary framework that spans the physical, chemical, biological, social and political sciences, as well as economics, engineering and law. Overall, the assessment will include an evaluation of the strengths, weaknesses, costs, and environmental impacts implicated by such transition scenarios, and offer informed conclusions on the extent to which renewable or other energy options are capable—or incapable—of adequately meeting the hydrogen challenge.

EESI believes that any instrument, whatever its form or designation, should be based upon and embody the results of an examination similar to what has been described above. However, the drafting of any particular instrument raises a cluster of issues not addressed in this EESI Proposal; and numerous questions surrounding such instruments must of necessity be postponed for the future. One question such is: Who will sponsor these instruments? Other questions pertain to the number of countries involved as well the subject matter. The prospect of negotiating a global treaty in law-making assemblies that include almost all nations of the world such as a Conference of the Parties under UNFCCC, or a freestanding framework convention on energy seems bleak. Comprehensive global agreements are notoriously difficult to negotiate and implement. It may be more feasible to consider drafting a targeted yet limited and functional instrument that includes OECD countries as well as stakeholder developing countries such as China and India. S&T and T&I agreements may be the easiest from a negotiating standpoint, but run the risk of fragmenting the necessary global response.

It is perfectly conceivable that targeted pragmatism may prevail over comprehensive idealism. Consequently, an ambitious protocol encompassing all sources of energy may prove too complex. Instead, consensus may form around a more narrowly tailored protocol that, for example, focuses only on de-carbonization and sequestration, space solar power or fission- fusion hybrid technologies. The UN Statute establishing the International Atomic Energy Agency (IAEA) stands out as a precedent setting treaty that deals with just one source of energy: civilian nuclear power. Numerous treaties addressing differing aspects of nuclear power have been negotiated under the aegis of the IAEA. More recently the U.S. has created an International Partnership for the Hydrogen Economy (IPHE) with 15 countries, including the EC and India, for advancing Hydrogen R&D. Moreover, the particular content and scope of the proposed draft energy instrument will depend on unfolding scientific, technological and geopolitical developments.

CONCEPTUALIZED FRAMEWORK



ENDNOTES

[1] The World Energy Council reports primary energy consumption for different countries based on rules for conversion of energy sources into primary energy. This accounting is a suitable method for comparing consumption of different energy sources in different countries.

[2] *See* Franklin M. Orr, Jr., White Paper: *Global Climate and Energy Challenge* (*available at* http://gcep.stanford.edu/pdfs/gcep_white_paper.pdf).

[3] Future energy scenarios are the product of developmental assumptions for complex demographic, socioeconomic and technological factors and may thus vary significantly. *See* Hoffert et al., *Advanced Technology Paths to Global Climate Change: Energy for a Greenhouse Planet*, 298 SCIENCE 981 (2002) (hereinafter Technology Paths); *Energy Implications of Future Stabilization of Atmospheric* CO_2, 395 NATURE 881, 883 (1998); IPCC, SPECIAL REPORT ON EMISSION SCENARIOS, 95–96, 221 (2000). One terawatt [TW] equals 1,000 gigawatts or one million megawatts.

[4] The EIA's "reference case" projects total world energy consumption will increase from 404 quadrillion Btu in 2001 to 640 quadrillion Btu in 2025—an average annual increase of 1.9 percent. *See* ENERGY INFORMATION ADMINISTRATION, INTERNATIONAL ENERGY OUTLOOK 2003 7 (2003).

[5] As a result of the increasing reliance of developing countries on fossil fuels—particularly coal, the most carbon-intensive of fossil fuels—despite lower projected energy consumption levels than that of the industrialized nations, CO_2 emissions from developing countries are projected to exceed those of the industrialized nations by the year 2020. In 2001 developing nations consumed about 64 percent as much oil as the industrialized nations; by 2025 they are expected to consume about 86 percent as much oil as the industrialized nations. *Id*. at 14.

The developing countries of Asia are projected to have the strongest energy consumption growth rate, accounting for nearly 40 percent of the entire projected increase in world energy consumption through 2025. *Id*. at 7, Table 1: World Energy Consumption and Carbon Dioxide Emissions by Region, 1990–2025. For developing Asia alone CO_2 emissions are projected to increase from 1.6 billion metric tons carbon equivalent in 2001 to 3.3 billion metric tons in 2025. *Id*. During this same period of time, total U.S. CO_2 emissions from energy use are projected to increase from 1.6 to 2.2 million metric tons carbon equivalent. ENERGY INFORMATION ADMINISTRATION, ANNUAL ENERGY OUTLOOK 6–7 (2003) (hereinafter AEO2003). Currently, the U.S. emits considerably more CO_2 from burning oil than any other country—e.g., more than Africa and Western Europe combined and 2.7 times as much as India and China combined. ENERGY INFORMATION ADMINISTRATION, INTERNATIONAL ENERGY ANNUAL, Table H2: World Carbon Dioxide Emissions from Petroleum Consumption, 1992-2001 (2001).

[6] The International Energy Agency (IEA) reports that through the year 2010 nearly 80 percent of the expected increase in the world's demand for oil is likely to be supplied by Kuwait, Iran, Iraq, Saudi Arabia, the United Arab Emirate, and the Caspian Region—with Venezuela as the only major low-cost, non-Middle Eastern petroleum producer. According to an assessment by the Center for Strategic and International Studies (CSIS), fully half of the world's oil demand will be met from countries that pose a high risk of internal instability by the year 2020. CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES (CSIS), EXECUTIVE SUMMARY: THE GEOPOLITICS OF ENERGY INTO THE 21ST CENTURY—REPORT OF THE CSIS STRATEGIC ENERGY INITIATIVE (2000). With half of the world's remaining conventional oil reserves, the Middle East is projected to meet almost two-thirds of the increase in global oil demand between 2003 and 2030. INTERNATIONAL ENERGY AGENCY, WORLD ENERGY INVESTMENT OUTLOOK 30 (2003).

[7] While experts disagree as to precisely *when* world oil production will peak, they are in general agreement that sooner or later this peak *will* occur. Estimates for world oil peak production range from 2004 to 2112—with a mean estimate of about 2037. The timing debate is essentially a dispute over the size of the world's endowment of recoverable oil—an amount consisting of global cumulative production, remaining reserves, reserve growth and undiscovered resources. THE ARLINGTON INSTITUTE, STRATEGY: MOVING AMERICA AWAY FROM OIL 29 (2003). In a probabilistic assessment study released in 2000, the U.S. Geologic Survey (USGS) estimated this endowment at approximately 3 trillion barrels of oil. On flip side of the debate, experts who disagree with this estimate generally posit the amount as being much closer to 2 trillion barrels. *Id*. *See also* U.S. GEOLOGICAL SURVEY, WORLD PETROLEUM ASSESSMENT 2000:

DESCRIPTION AND RESULTS, Table 2: World Estimates, Conventional Oil Resources and Reserve Growth (2000). The world's total oil demand is projected to increase from 76.0 million barrels per day in 2001 to 123 million by 2025. To meet this growth in demand, worldwide refining capacity is expected to increase from 81.2 million barrels per day in 2002 to almost 133 million barrels per day by 2025—an expansion of 64 percent. AEO2003, *supra* note 5, at 52–54 (2003).

8 *See* R.B. CHENEY ET AL., NATIONAL ENERGY POLICY: NATIONAL ENERGY POLICY DEVELOPMENT GROUP (2001).

9 Technology Paths, *supra* note 3, at 981.

10 As set forth in the seminal Brundtland Report, sustainable development is described as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." REPORT OF THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT (WCED), OUR COMMON FUTURE 54 (1987). The report further notes that "[i]n essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations." *Id*. at 57.

11 In addition to other relevant provisions of the UNFCCC, Article 4(5) commits developed country Parties to "take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention."

12 DOE, DRAFT STRATEGIC PLAN 13 (2003).

13 *See* DOE, Revised Draft: TERMS OF REFERENCE FOR THE INTERNATIONAL PARTNERSHIP FOR THE HYDROGEN ECONOMY (2003).

14 Technology Paths, *supra* note 3, at 983.

15 IEA, ENHANCING THE MARKET DEPLOYMENT OF ENERGY TECHNOLOGY 16 (1997).

16 George Gilboy, *The Myth Behind China's Miracle,* FOREIGN AFFAIRS, July/August 41 (2004).

17 Vaclav Smil, ENERGY AT THE CROSSROADS 277–78 (2003).

18 *Id*. at 984.

19 Hoffert et al, *Response*, 300 SCIENCE 583 (2003).

20 *Id.*

21 *See generally*, DOE, A NATIONAL VISION OF AMERICA'S TRANSITION TO A HYDROGEN ECONOMY (2002); DOE, NATIONAL HYDROGEN ENERGY ROADMAP (2002).