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Sustainable Energy in a Developing World: The Role of Knowledgeable Markets

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Abstract

Free markets lack vision. The principle of sustainability, however, can provide vision to the free market system. The vision of sustainability, though, must be translated into a language the market understands. The primary tool of translation is ?sustainability knowledge?. What is true of the marketplace in general is also true of the energy sector of the marketplace. In this paper we attempt to illuminate some of the *knowledge-related processes* necessary for implementing the vision of market-based sustainable energy. Three knowledge-related processes are distinguished: 1) generation of knowledge related to energy sustainability, 2) dissemination of this knowledge, and 3) application of the knowledge to public and private sector decisions related to energy markets. These processes pertain to both developed and developing countries of the world, however, in this paper special attention is given to issues related to knowledge, energy and markets in developing countries.

Sections 2 and 3 of the paper spell out the magnitude of the problem faced by those who generate, disseminate and apply sustainable energy knowledge. Section 2 describes trends and projections in worldwide energy demand, and points to the fact that the energy dilemmas of both developed and developing countries will not only intensify but also become increasingly intermeshed in the future. Section 3 consolidates this point by describing what is called the global ?Energy Market??the linked and synergistic whole of local, national, international and global energy markets, energy actors, and energy-related market forces?which is an entity over and above the global ?energy market? which consists only of markets in certain internationally traded fuels and energy services. It is the total Energy Market which must attain sustainability.

Section 4 briefly defines the concept of sustainability as it relates to energy use. Sustainability is defined to consist of three dimensions: ecological, social equity and political security. To illustrate the breadth of knowledge processing required for realizing the sustainable energy vision, some of the knowledge demands related to ecological impacts of energy use are described.

Section 5, the heart of the paper, details the relationship between knowledge, energy and markets. It begins with an explanation of the theoretical relationship between knowledge and markets, and then moves into a description of the relationship between sustainability knowledge and the Energy Market as it relates to each of the knowledge generation, dissemination and application processes. Generation of knowledge is characterized in terms of types of knowledge, who generates them, and how they are generated. Dissemination of the knowledge is depicted as the process plugging it into the knowledge pool of civic society and its governance structures. And application of the knowledge is described in terms of the final market-relevant forms into which the knowledge can be absorbed (for example, emissions taxes or wind turbine demonstration projects).

The concluding Section 6 proposes that there must be increasingly conscious attention to the design of sustainability knowledge systems (of generation, dissemination and application) in the energy sector so that the vision of sustainable energy can be made global, participatory and self-generating.

1. Introduction

Visions invigorate. The vision of sustainability can invigorate a global economy dominated by the free market system. Free markets are a powerful social invention for the efficient allocation of scarce resources, but free markets in and of themselves can not and will not produce sustainability. Free markets are not generators of collective vision. The creation of vision(s) of sustainability is what we might call a ?meta-market force?, for it involves social, political and cultural forces that fall outside the purview of market operation and more conventional ?non-market forces?.

Visions of sustainability must be translated into practice. An essential, and often overlooked, aspect of the translation process is the role of knowledge. Knowledge mediates between vision and practice. ?Sustainability knowledge? (knowledge produced in service to the goal of achieving a sustainable civilization) must be generated, synthesized, summarized, codified, disseminated, debated, reviewed, evaluated, brokered, applied and entrenched for the sustainability vision to take root. A gargantuan task for global civic society in the 21st century will be to generate and deploy sustainability knowledge in all sectors of the global economy.

One sector is the energy sector. The governing vision of sustainability for the energy sector is ?sustainable energy?, and knowledge related to sustainable energy must be generated and deployed in order to attain this vision. In this paper we attempt to illuminate the role of knowledge in implementing the vision of sustainable energy in the marketplace. The implementation process is seen to consist of three related processes: 1) production of knowledge related to energy sustainability (for example, creation of ?green?

indicators), 2) dissemination such knowledge (for example, distribution of green indicators via the internet), and 3) application of the knowledge to private sector decisions (for example, use of green indicators in full-cost pricing) and to public sector decisions (for example, use of green indicators in national income accounts).

Though much of our discussion is generally applicable to all nations of the world, we pay special attention to the relationship between knowledge, energy and markets in low-income (also referred to here as ?developing?) countries. In particular, we wish to address how sustainability knowledge can be generated and applied in the marketplace in lower income countries to help resolve their energy dilemmas. However, as will be amply demonstrated in the next two sections, achieving sustainable energy in the developing world is inextricably bound to achieving it in the developed world.

2. Worldwide Growth in Energy Demand: Trends and Projections

The process of economic and social development is invariably accompanied by an increase in the need for energy and ?energy services?. Energy services are services?provided through the use of fossils fuels, biomass, fissible materials or other energy sources?that help to satisfy human needs and desires. Examples of energy services are almost unlimited. They include the boiling of drinking water in Nepal, grilling of tortillas in Mexico, firing of a tea cup in Japan, welding of a Tata automobile in India, and rocketing of an F-4 Phantom off an aircraft carrier in the Persian Gulf. The form of development which is most intimately associated with vast increases in the use of energy services is ?industrialization?.

It is rapid industrialization, combined with large populations, in low-income countries, or in countries with economies in transition, that will likely drive the biggest future increases energy use. If we examine the relationship between energy use and development in an industrial economy, then we find first of all that economic growth is strongly coupled with energy use. In the decades leading up to the 1970s there was essentially a linear relationship between economic growth and energy use in industrial countries. Though there seems to have been a ?decoupling? from a linear relationship, there is still a ?positive? relationship. In other words, an increase in gross domestic product (GDP) is still associated with an increase in energy use, though it is less than 1:1. In the developing world, in its almost unanimous drive to industrialize, there is a strongly ?positive? relationship, although it is difficult to characterized because of the multiple forms and levels of development.[1]

As of 1995, the total amount of primary commercial fuels (including coal, petroleum, natural gas, hydroelectricity, and electricity from nuclear plants) stood at approximately 324 exajoules (EJ)[2], or about 7.74 billion tonnes of oil equivalent. Of this total, 53 percent was used in OECD countries (sometimes referred to as the ?industrialized? countries), 15 percent in the countries of Central/Eastern Europe and the former Soviet Union, and 32 percent in the rest of the world.[3] Although the distinction between ?developing? and ?industrialized? regions is blurry, the ?rest of the world? category includes virtually all of the lower-income countries of the world, including those in Africa, Central and South America, and much of Asia. Figures 1a and b show the division of primary energy use in 1995 by fuel type and by region or sub-region, respectively. Oil accounted for the largest fraction of global energy use, followed by coal, natural gas, and primary electricity. North America was the region which consumed the greatest fraction of energy followed by Europe, the former USSR, and China.

[Fig. 1a and b]

The global distribution of energy use has changed markedly, even over the last 10 years. Table 2-1 shows, for 1985, 1990 and 1995, the division of global primary energy use by fuel and by area. Although overall energy use in OECD countries and in the countries of Central/Eastern Europe and the Soviet Union has grown only modestly? or even declined? over the last decade, growth in energy use in developing regions has been strong, particularly in China and other Asian countries. Note that the figures in Table 1 do not include biomass fuels, which hold substantial shares of overall energy supply in many developing countries.

[Table 1]

Projections and scenarios of future energy use suggest that the trend of the last decade of increasing use of fuels in ?developing? regions relative to ?industrialized? regions is likely to continue and possibly accelerate. Table 2 shows ?Reference Case? projections published by the U.S. Department of Energy?s Energy Information Administration (USDOE/EIA) for global energy use by fuel and by region in 2005 and 2015.[4]

Starting in 1995, energy use in developing regions is projected to grow at an average rate of about 3.6 percent per year through 2015.[5]

By 2015 energy use in developing regions increases to over 41 percent of the global total from 32 percent in 1995. Projections by other researchers show a similar pattern.[6]

[Table 2]

The above section establishes several critical facts: 1) energy use is coupled with growth in an industrial economy, although the coupling may not necessarily be linear, 2) economic growth in both developed and developing countries is projected to increase in the next two decades and hence energy growth is projected to increase, and 3) developing countries? share of global energy use relative to industrialized countries is projected to increase. These facts combine to suggest that coping with the global impacts (ecological, social, economic, political and technological) of energy use poses a major challenge for the 21st century, and will create energy dilemmas not only for developing nations but also for developed nations.

Can market forces in the energy sector be harnessed to achieve long-term sustainability in energy use in both developed and developing countries to mitigate or prevent the potentially devastating impacts associated with economic growth? Before attempting to answer this, we need to examine more closely the character of the marketplace in the energy sector.

3. The Global Energy Market

3.1 Global Interdependence

One of the single most important economic changes in the world today is simply the fact that the use of free markets is exploding. There has been a dramatic shift away from ?command and control? or ?centrally planned? (socialist) economies to free market economies. Nothing better illustrates this point that the rush to free markets by the countries of Eastern Europe and the former Soviet Union, and China?s experiment with free market forces. This monumental change means that the free market system, with all its goods and evils, is both the world?s dominant economic system, and, the system within which nations? energy relations are determined.

The explosion of free markets has intensified the phenomenon known as ?global (economic) interdependence?. Global economic interdependence in the energy sector is exemplified by the tremendous growth in internationally traded, financed and produced energy. Global economic interdependence has in turn also helped foster recognition of our ?global (social, political and ecological) interdependence?, that is, recognition that human well-being in one corner of the world is increasingly tied to social, political and ecological well-being in other corners of the world. The multiple forms of global interdependence signal that in a very real sense we can talk about a global Energy Market (upper case) which ties together all energy-related market activities, whether local, national, international or global in scale. The Energy Market stands in contrast to the global energy markets (lower case) which ties together only internationally traded, financed and produced energy. Our task in this paper is to illuminate the role of knowledge in implementing the vision of sustainability in the global Energy Market. Before we proceed , however, we need to ground our discussion by looking at the composition of the so-called Energy Market.

3.2 Composition of the Global Energy Market

The Energy Market consists of numerous energy markets which encompass the buying and selling of fuels and the energy infrastructure within which fuels are transformed and ultimately used to provide energy services. Energy markets range in scale from global (for example, oil) to local (for example, firewood). Some of the smaller energy markets operating within the larger Energy Market can be categorized as follows:

Markets for fossil fuels: Markets for crude oil and petroleum products are global in scale, and are largely dominated by a relatively few major multinational companies and national crude oil suppliers. Coal markets are increasingly becoming global, although coal production in much of the world (including developing countries) has been traditionally state-owned. With the marked expansion of facilities for handling liquefied natural gas (LNG), the natural gas market has been shifting from primarily regional markets (using gas pipelines) to a nascent global market as well.

Markets for traditional renewable resources: Markets for biomass fuels have traditionally been local in nature, with individuals and small businesses doing the bulk of the trading. In some developing countries, markets for charcoal have become national in nature, sometimes even crossing international borders, and larger companies or cartels have sometimes become involved.

Markets for conventional energy supply infrastructure: Large companies, including a number of multinational firms, dominate the provision of infrastructure for fuel extraction (coal, oil and gas), for oil refining, for thermal, hydroelectric and nuclear power generation, and for electricity transmission and distribution. Larger developing countries sometimes have their own industries for producing these types of equipment?particularly in smaller sizes?both for domestic use and for export. Buyers of energy infrastructure have traditionally been state-owned companies or utilities, but there is a global trend toward the developers of energy facilities acting as facility owners and/or operators.

Markets for non-conventional/renewable energy supply infrastructure: The supply of infrastructure for renewable energy conversion?notably solar photovoltaic and wind power systems?has changed in recent years, with fewer and larger firms becoming dominant globally. Purchasers of renewable energy infrastructure vary in scale from individuals to nations.

Markets for end-use appliances and equipment: Most major electrical and gas appliances, motor vehicles, and other major energy-using devices tend to be manufactured by, or manufactured under license to, large national or multi-national corporations, while buyers are individuals/households, firms and institutions.

Markets for energy-efficiency technologies: Sellers of energy-efficiency technologies are a combination of smaller and larger companies. Most of these devices are ultimately purchased by end-users (individuals, institutions and businesses), although governments and utilities have sometimes played the role of ?middleman? in these markets.

Markets for capital: The availability of financial capital is an overarching consideration in the development and functioning of markets for fuels and especially infrastructure. In many cases, growth in demand for financing of energy infrastructure in developing countries is and will be well beyond the abilities of government and local financial institutions to provide. This means that external financing?multinational commercial and multilateral institutions?will have to fill the gap. Thus, the investment criteria of global financial institutions will play a large role in determining what type of energy systems evolve in developing countries, as well how environmentally-sustainable those systems are.

Energy-sector actors in the above-described markets include:

Multilateral organizations and lenders: The United Nations, World Bank, the Global Environment Facility, the Asian, African and Inter-American development banks, the Asia-Pacific Economic Cooperation (APEC) Forum, and other international and multi-national organizations fulfill a number of roles in the energy sector of developing countries. These roles include funding research, development and demonstration projects, providing or arranging financing for energy infrastructure, providing assistance with energy planning and with energy-related economic development, tracking statistics from the energy sector, and transmitting information between various energy-sector actors.

Multinational private corporations: Private corporations operating across national borders provide a substantial portion of the globally traded fuels, large energy installations, and energy demand equipment. Private corporations also play a major role in prospecting for and extracting fossil fuels, as well as in research development, demonstration and commercialization of new energy-sector technologies. Also, industrial facilities in developing countries that are owned by multinational companies can be major demand centers for electricity and/or other fuels? thus, multinational companies can have substantial leverage in setting energy policy.

National corporations: State-owned corporations, including natural gas and electric utilities, oil and coal companies, have traditionally had a dominant role in the energy-supply sector in developing countries.

Larger private firms within nations: In some developing countries, large private firms serve as utilities and fuel suppliers, and also help shape both energy infrastructure and energy policy as suppliers of energy-using devices and as industrial/commercial consumers of fuels and energy-sector equipment.

National research and development (R&D) institutions: Most industrialized nations and some developing countries have publicly and/or privately funded institutions devoted to aspects of energy technology development. Often these are organized by fuel type (for example, the Central Research Institute of the Electric Power Industry (CRIEPI) in Japan), or by other topic areas (for example, the Beijing Energy Efficiency Center in China).

National and sub-national regulatory agencies: Domestic regulatory agencies are charged with setting energy and environmental standards, as well as with energy planning tasks. The regulation of energy pricing is a role often served by national agencies, although regulation in the energy sector is generally declining at present.

Non-governmental organizations: Interest groups outside of the government play various roles, including acting as advocates for consumer groups and indigenous peoples, as environmental ?watchdogs?, and as agencies to promote (or oppose) particular energy technologies or paths.

Smaller private firms: Smaller private firms play multiple roles, including supplying technologies for energy conversion and energy demand equipment, supplying fuels such as biomass and charcoal, and consuming both fuels and energy-using devices.

?**Local**? **Communities**: Local communities include state and provincial governments, cities, traditional villages, etc. These entities can act as both buyers, sellers and managers of energy. Traditional rural villages, for instance, administer traditional energy forms such as agricultural wastes, wood fuel and charcoal produced locally while at the same time administering industrial fuels such as electricity (in rural electrification schemes) and kerosene fuels sold in rural areas.

Individual consumers: Households and individuals are the final consumers of fuels and energy goods and services. As such, their preferences expressed via their ?political votes?, ?monetary votes?, and other economic/political actions help to determine which fuels and energy consuming devices prevail in a particular country.

The above description of energy markets and energy-sector actors, while hardly complete, is sufficient to demonstrate that the operation of the marketplace in the energy sector is highly complex. The synergistic sum of all energy markets, forces which shape these markets, and actors within the markets constitutes what we have called *the* ?Energy Market.? It is this vast and loose-knit entity that must be made to function in a sustainable manner, and to which colossal amounts of sustainability knowledge must be applied so that it properly functions in this manner.

4. Sustainability & Energy

4.1 The Concept of Sustainability

There is no accepted definition of ?sustainability?.[7] This is as it should be. Sustainability is a changing process, not a stable state. Generally, use of the term acknowledges that things are out of balance in our current practices of living on Earth, and that the imbalances, if not corrected, will diminish future generations? ability to live fulfilling lives. At a more specific level, use of the term ?energy sustainability?

acknowledges that our current practices of energy extraction, transformation and end use are out of balance. The authors simply envision sustainability as an umbrella concept for expressing the interconnectedness of the out-of-balances. We see sustainability as being composed of (at least) four key dimensions: preservation of ecological integrity? the natural dimension, pursuit of human justice and equity? the social dimension, maintenance of peaceful community? the political dimension, and achievement of economic efficiency? the economic dimension. The first three as they relate to energy will be explained in turn. The fourth is the theme of this paper.

Energy use inevitably affects the environment. It is impossible to eliminate all impacts, but it is not impossible to keep impacts within the limits of ecological integrity. Over the past centuries, especially in the industrialized world, energy use has caused increasingly widespread and severe environmental impacts. This trend was first clearly recognized in the ? environmental revolution? of the late 1960s and early 1970s. A complete rethinking about energy use and its relation to ecological issues ensued, and led to such ideas as the ? soft? energy path[8], energy efficiency and demand-side management[9], and a solar-based society. It is now widely accepted, if not realized in practice, that concerns about damage to ecological integrity must be included in decisions about use of ? industrial? and non-industrial energy.

Energy use affects patterns of social equity and cultural diversity. Pursuit of social justice and cultural integrity are part of sustainability. For example, access to energy must be such that basic human needs are met? sustainability in energy use can never be built upon human suffering. Also, energy use must be allocated such that legitimate aspirations for economic development can be attained?sustainability can never be built upon suppression of the desire for human betterment. Social equity can be thought of having four realms along two axes: intra- and inter-national equity (the spatial axis), and intra- and inter-generational equity (the temporal axis). Often sustainability is associated only with intergenerational equity. It is now widely accepted, if not realized in practice, that all four social dimension of sustainability must be incorporated into decisions about energy.

Energy use impacts political relations. This was first driven home in the international arena by the ?oil shocks? of the 1970s, and further driven home by the Gulf War. In both instances, patterns of energy use demonstrably affected military postures and geopolitical relations. To attain sustainable energy use there needs to be peaceful development, meaningful participation in decision-making, and a reasonable assurance of national ?energy security?. It is now widely accepted, if not realized in practice, that the political and security dimensions of sustainability must be incorporated into decisions about energy.

There are sure signs that our present patterns of energy use are not sustainable. Environmental impacts seem to be spreading and growing more severe. Social inequities seem to be increasing. And nations seem to feel more insecure about their energy future, not more secure. Of all the symptoms of unsustainability in energy use, none may be more telling than the seemingly irreversible ecological impacts of energy use. For this reason, and to set a concrete base in one of the sustainability dimensions for our visualizing the role of knowledge in sustainable energy, we will look more closely at some of the ecological impacts of energy use.

4.2 Ecological Sustainability & Energy

This section provides a brief sampling of some of the direct and indirect impacts that energy use can have on the global ecology.[10]

Some attention is paid to impacts on social equity and political security, but the main focus is on impacts on ecosystems. The reader should keep in mind that understanding only a small portion of the sum total of ecological impacts of energy use, let alone social and political impacts, will demand the generation, dissemination and application of knowledge on scales never before attempted.

Global Climate Change: Perhaps the most potentially disruptive environmental change due to increased energy use is a permanent alteration in the Earth?s atmospheric composition and its attendant effects on climate. Environmental impacts of global climate change include: changes in average temperature, rising sea levels, changes in precipitation and in the frequency and severity of storms, and changes in the distribution of ecosystems.

Acid Deposition: Acid deposition, or ?acid rain? as it is commonly termed, is the deposition of acidic compounds on the Earth?s surfaces. The primary acidic compounds are oxides of sulfur and nitrogen (SO_x and NO_x) produced during combustion of fossil fuels. Acid deposition is at once a local and regional problem depending on emission and meteorological conditions. The major sources of acidic compounds are fossil fuel combustion in power plants and motor vehicles, and smelting activities. Acid deposition in Europe, North America, and East Asia has already been implicated in acidification of inland water bodies, declining health of forests, premature weathering of metals and other human-made materials, and degradation of irreplaceable cultural artifacts.

Marine Pollution: Pollution of the marine environment through energy exploration, extraction, transport and use is another energy-related environmental impact. The most visible example of marine pollution is "oil spills". Crude oil and refined products spill during routine operation of offshore oil rigs, from oil tanker filling and off-loading operations, during the cleaning of tankers, as spillage from other (non-tanker) ships that use petroleum fuels, and as a result of leakage from undersea pipelines, as well as during less frequent but better-publicized oil tanker accidents and "blowouts" at offshore oil platforms.

Urban air pollution: Urban air pollution results primarily from the combustion of fossil and biomass fuels in the industrial, residential, transport and other sectors in urban areas. Local geography and wind patterns often play a role in exacerbating pollution problems. Pollutants such as carbon monoxide, nitrogen and sulfur oxides, hydrocarbons, and particulate matter (soot) have a negative effect on urban natural environments, as well as the more-publicized effects on human health, economic infrastructure and cultural treasures.

Water pollution: Energy-sector activities contributing to the contamination of rivers, lakes and oceans include discharge of wastes from refineries, discharge of "blowdown" water (solutions of water, ash and cleaning chemicals) used to clean utility and industrial boilers, runoff from coal ash piles, and discharge of waste oils from the transport sector. Leachates carrying acids and heavy metals drain from coal, iron and other mines, and from piles of overburden from mining and tailings from processed metal ores. Thermal power plants (nuclear and fossil-fueled) located on rivers and oceans often discharge heat into bodies of water, changing the local aquatic or marine ecology.

Solid wastes: Solid wastes from the energy sector are mostly generated during the processing and combustion of coal. Coal ash (and coal processing wastes) often contain heavy metals and other toxins that can leach into water supplies if wastes are not properly disposed of.

Biodiversity: Energy-sector activities with a negative impacts on the diversity of wildlife in a given area include inundation of large areas by hydroelectric impoundments, oil and gas exploration and extraction, coal mining and coal waste disposal, land changes due to use of biomass fuels and establishment of biomass fuel plantations, and siting of energy facilities (such as power plants and refineries) in formerly wild areas.

Displacement of animal/human populations: The most obvious source of ?involuntary? shifting of animal and/or human populations is inundation of large areas as a result of hydroelectricity development (for example, the Three Gorges Dam in China), but similar shifts result 1) directly from other types of energy developments such as oil development on lands inhabited by indigenous animals and native peoples, and 2) indirectly from pollution such as release of toxics from nuclear waste storage sites.

Nuclear waste and weapons proliferation: Generation of electricity in nuclear reactors generates several different types of radioactive waste (low-level, high-level, and spent fuel) that include a variety of radioactive and/or toxic products, many of which persist for thousands of years. Radioactive materials are a ?natural? part of the environment but not in their current ?unnatural? concentrations and distributions due to human manipulation. Proper isolation of radioactive wastes is technically complex, and there is fierce controversy over the desirability and feasibility of waste which requires such extreme care in its disposal. Besides the environmental impacts of nuclear materials, there is a high degree of concern over their security impacts. Stringently safeguards are mandatory in order to prevent for their diversion for use in nuclear weapons. Thus, this ?energy security? issue associated with use of fissible materials logically fall under the purview of sustainability issues.

The above exposition of some of the ecological impacts of energy use gives witness to the complex job of generating and applying sustainability knowledge in the energy sector of the market economy. With this realization, we can now turn to an examination of role of knowledge in implementing the vision of sustainability in the Energy Market.

5. Knowledge & Sustainability in the Energy Market

5.1 Knowledge & Markets

The key question before us is: ?How can sustainability knowledge be produced and incorporated into both public and private sector decisionmaking such that it serves to configure, constraint, cajole and coordinate market forces in the energy sector in the direction of a sustainable future?? Before we plunge into this question, an understanding is needed of some of the elementary principles of the functioning (and ?disfunctioning?) of markets and their relation to knowledge.

F.A. Hayek succinctly stated the economic problem of society as:

> ?not merely a problem of how to allocate ?given? resources?if ?given? is taken to mean given to a single mind which deliberately solves the problem set by these ?data.? It is rather a problem of how to secure the best use of resources known to any of the members of society for ends whose relative importance only these individuals know. Or, to put it briefly, it is the problem of the utilization of knowledge not given to anyone in its totality.?[11]

Thus, the economic problem of society at root is a knowledge problem. There is no one ?super mind? in society that can know the total resource base and how best to use it. Thus, how do resources get valued and distributed? The free market system solves this problem by capitalizing on the fact that the two end points in economic exchange?producers and consumers?know best the terms of exchange that suit their preferences, although each possesses only scattered and fragmentary knowledge. This ragged set of knowledge meets in a decentralized decisionmaking forum?the marketplace?and almost miraculously results in an orderly, knowledge-based system for ?efficient? allocation of scarce resources. The problem with the current self-interested knowledge in the marketplace, though, is that it is deficient in one major respect; it is knowledge lacking in a consistent sustainability self-consciousness.

It is prudent at this point to pause for a moment and clarify how the word ?knowledge? is being used in this paper. It is being used loosely. Information (for example, data on sales of compact florescent light bulbs), organized information (for example, scientific theories of conversion of solar energy to electricity), collective experience (for example, personal histories of coal mine workers), and wisdom (for example, the sayings of Confucius) all fall under our use of ?knowledge?. More refined distinctions can be made, but for the purposes of this paper they are not necessary.

The modern market system is a product of the transition from feudalism to capitalism which occurred in Europe beginning around the 13th century, and was fundamentally based on the ?commodification? of resources such as land and labor. Polanyi called the emergence of the modern market (or Market, as he designated it) the ?Great Transformation?.[12] It transformed the ways in which goods were produced, that is, it vastly expanded the type of commodities which could be traded in the marketplace. The information (or knowledge) content of a commodity was essentially expressed in its price. This is the narrow view. The broader view is that the knowledge content was also expressed in the institutional structures that defined what constituted a commodity.

But markets also proved fallible; they could not incorporate the full range of knowledge humans possess nor the full range of choices with which humans are faced. There are spheres in which markets do not function well. The most common way of terming the dysfunctional aspects of markets is as ?market failures?, and one of the most common market failures is ?externalities?. It is these cracks and chasms in the foundation of a free market economy where we often find the specific sources of unsustainable behavior, and which need to be bridged with sustainability knowledge.

5.2 Sustainability Knowledge & the Energy Market

Sustainability knowledge serves multiple purposes related to the Energy Market. It can serve the purposes of setting long-term objectives for energy supply and demand (for example, achieving a fossil fuel free future), establishing international norms and values related to energy use (for example, assuring that basic human energy needs are met), building energy-related institutions and infrastructure (for example, constructing regional natural gas pipelines together with their regulatory systems), and monitoring progress toward sustainable energy (for example, launching a wet deposition monitoring network). The application of energy-related sustainability knowledge to Energy Market dynamics consists of the following three steps: 1) generation of knowledge, 2) dissemination of the knowledge, and 3) its attachment public and private sector market-related decisions. Each of these processes will be examined in turn.

<u>Generation of Sustainable Energy Knowledge</u>. To implement the sustainable energy vision, a wide variety of knowledge types are required. The following (overlapping) types can be distinguished: sustainability indicators, baseline information, market failure knowledge, market sustainability knowledge, and exploratory knowledge. Each will be explained.

Sustainable Energy Indicators. One of the most critical types of knowledge is sets of practical indicators, criteria, measures, etc. which can be used to define and judge the realization of the sustainable energy vision. These indicators include economic indicators such as growth, employment, income and price indices, social indicators such as demographic, education, nutrition and health guides, and environmental indicators such as air, water and soil quality, and resource depletion levels. Specific energy-related indicators would include economic indicators such as local and national energy efficiencies per unit of economic output, social indicators such as levels of rural electrification, and environmental indicators such as carbon dioxide concentrations in the atmosphere.

Because of the nature of the market system, it is imperative that a significant collection of *quantitative* indicators be developed. As has already been stated, the market is fundamentally based on the quantitative principle of ?commodification?, in which commodity transactions are mediated by ?price??a negotiated, but quantitative measure of consumer utility and producer profit. Thus, to mold itself to market dynamics, quantitative measures of energy sustainability must be generated. Much work is already being expended in this direction. Organizations such as the United Nations Environment Programme (in their Earthwatch program), the World Resources Institute (in its annual *World Resources* publication), and the Worldwatch Institute (in its annual *State of the World* and *Vital Signs* series) are engaged in broad definition of sustainability criteria.

Not only will there be numerous types of sustainability knowledge required, but numerous methods will be used to obtain the knowledge. As one example, creation of sustainable energy indicators related to ecosystems is a domain where scientific methods will dominate. That ecosystems are too complex for science to provide definitive limits, tolerances, levels, thresholds, etc. is granted; the so-called ?precautionary principle? is admission of such. However, the success that science has had in explaining ecological interactions, and the absence of widely acceptable of alternatives in the public sector to scientific reasoning, has led to science assuming a role as arbiter of criteria of ecological sustainability.[13] Evidence of this role comes from the evolution of the 1979 Convention on Long-Range Transboundary Air Pollution in Europe in which criteria of ecological sustainability in the form of scientifically determined ?critical loads? is becoming the normative base for international decisionmaking on the acid deposition issue in the region. Another piece of evidence, albeit less clear-cut, comes from the 1990 U.S. Clean Air Act where the national ceiling on sulfur dioxide emissions from coal-fired power plants was in part determined by scientific evidence on the tolerance of inland water bodies in North America to acidic inputs. Using science to determine ecologically-based ceilings, tolerances, doses, etc. of ecosystems to pollutant emissions, and then letting market forces figure out how best to stay under the given targets is a trend in sustainability knowledge in the global Energy Market that the authors see becoming increasingly important.

Baseline Energy-Related Information. Baseline information involves the gathering of coordinated sets of data on the present or past state of a given Energy Market domain. Baseline information is ?raw data?. Examples include field surveys to determine the damage to tree species by acid deposition in a given area, interviews with residents threatened by dislocation due to construction of a large dam, data on amounts and locations of radioactive waste within a country?s borders, lists of all energy efficiency technologies potentially accessible to low-income countries, and profiles of banks investing in energy infrastructure. Baseline information is the raw material with which higher forms of organized information, such as sustainable energy indicators, are constructed.

Energy Market Failure/Sustainability Knowledge. The distinction between energy market failure and energy market sustainability knowledge is premised on the fact that even if governments instituted policies to eliminate all energy market imperfections, thus making the global Energy Market operate at peak efficiency, this package of idealized policies would not produce sustainability. In other words, efficient markets will not automatically result in sustainability. Restoring efficiency to a market will move it toward sustainability, primarily by eliminating economic waste associated with misallocation of resources, but by itself is not a sufficient condition for sustainability. Thus, although there is great overlap in these two categories of knowledge, they are distinguished by the fact that the principal knowledge generation effort is directed either toward correcting market failures or toward injecting sustainability consciousness in the Energy Market. Examples of market failure knowledge include: knowledge which increases the transparency of energy related transactions, restores competition to cartelized natural resources markets, restricts access to common resources, and redefines property rights. Examples of market sustainability knowledge include: knowledge which attends to basic human needs, addresses the issue of systemic failure in the global economy, integrates energy security and environmental security thinking into economic thinking, confronts the human psychological limits of information absorption, and deals with economic rationale for environmental racism. It may help the reader to think of market failure knowledge as microeconomic, policy applied knowledge, and market sustainability knowledge as macroeconomic, systems thinking knowledge, although this classification should not be held to rigorously.

Exploratory Energy-Related Knowledge. The last category of knowledge, exploratory knowledge, is knowledge which addresses subject areas that push the horizon of knowledge applicable to a sustainable energy future. This includes technological research and development, creation of models (biogeochemical, energy and/or economic) for generating future scenarios, experiments with information processing technologies, think tank projects on designing of new institutional arrangements of sustainable overseas development assistance (ODA), etc.

Having examined some of the types of knowledge required to implement the sustainable energy visions, we next ask *how* is such knowledge generated and *who* generates it? The bottomline answer as to who generates such knowledge is: all citizens of Earth. Because everyone uses energy and because sustainable energy issues stretch in scale from local to global, all people are participants in devising energy-related sustainability knowledge. We will return to the global participatory nature of sustainability knowledge, but for the moment we will concentrate only on the role of ?experts? in generating such knowledge.

Experts and expert knowledge have a key role to play in the creation of the types of sustainable energy knowledge described above. As has already been alluded to, generation of sustainable energy indicators will primarily be the province of experts (scientists, economists, planners, medical doctors, etc.). And for better or worse, scientific sorts of reasoning are likely to be the dominate method of creation. Input from non-scientific methods of thinking will be critical, but because of the market-dictated necessity of producing quantitative sustainable energy criteria, scientific methods which are steeped in mathematical expression will be turned to first.

Generation of sustainability knowledge is unequivocally a collective effort. Indeed it requires a *massive* collective effort, and a wide variety of collectivities of people? non-governmental organizations (NGOs), marketing agencies, trade associations, and interdisciplinary research teams? will be and are already engaged in generation of such knowledge. All of these collectivities can not be discussed here, but in keeping with a focus on creation of fundamental sustainable energy knowledge, one form of collectivity that is vitally important is ? epistemic communities? .[14] Epistemic communities are multidisciplinary networks of credentailled experts engaged in a common policy project. The common policy project may be acid deposition in East Asia, development of clean coal technology in the United States, or rural electrification in East Africa. The essential function of epistemic communities is to generate *policy-relevant* knowledge, which means they synthesize, summarize, interpret and translate esoteric forms of fundamental knowledge into forms understood by policymakers.

Generation of sustainability knowledge in addition to being collective is unequivocally multi- and inter-disciplinary. Epistemic communities, for instance, are almost by definition interdisciplinary teams. The trend of introducing sustainability knowledge into marketplace decisionmaking, will initiate a quantum leap in the amount of interaction between various disciplinarily isolated experts, and between experts and lay people. For instance, creating an effective set of sustainability criteria will require multidisciplinary teams of scientists, economists, political scientists, policy analysts, historians, planners, demographers, sociologists, etc.

Dissemination of Sustainable Energy Knowledge. Generation of sustainability knowledge means nothing if it is not disseminated to appropriate parties. The dissemination function is distinct from the generation function because often those who participate in channeling knowledge are not be the same as those who create it. Dissemination actually involves a number of processes including collecting, synthesizing, summarizing, codifying, evaluating, interpreting and transmitting knowledge, and those (outside of the knowledge generators themselves) who engage in dissemination can be termed ?knowledge brokers.? Ultimately knowledge brokers seek to inject sustainable energy knowledge into the pool of knowledge available to civic society and to its governance structures.

Given that civic society and its governance structures range in scale from local (for example, neighborhood associations) to global (for example, the United Nations), there is need for mechanisms for processing the scattered and fragmentary sustainable energy knowledge on all these scales. One mechanism is a loose global network of sustainable energy knowledge-makers and knowledge-brokers linked via the internet by ?information appliances? (PCs, network PCs, web TVs, cellular phones, satellite technology, etc.). Information technology has the potential of making sustainable energy knowledge not only accessible but also participatory.

Application of Sustainable Energy Knowledge. How is sustainable energy knowledge incorporated into market-related public and private sector, local and global, short-term and long-term decisions? There are a myriad of methods and forms of incorporation. Below is a listing of just a few of the final incarnations of the applied knowledge. The listing proceeds from those most relevant to developing countries.

Basic Human Needs. Eradication or deep reduction of poverty is an essential requirement for the proper functioning of a sustainable global economic system. Widespread poverty will eventually undermine the global marketplace through such traumas as large-scale civil unrest, massive movements of people, or collapses of national governments. Because a market is ultimately based on considerations of economic efficiency, not human equity, even properly functioning markets have no incentive to eliminate poverty. But it must be recognized that it is in the long term interest of the market system to make itself subordinate to certain social sustainability criteria such as meeting basic human needs.[15] Knowledge needs to be developed on levels of needs and how best to meet them via market and non-market strategies.

Knowledge Capacity-Building. In what should be a positive feedback loop, generation of sustainable energy knowledge should generate commitment to improving education around the globe, especially in developing countries. This involves increasing literacy rates among the general population, and increasing access to higher education among the most talented in the population. High levels of education are necessary for all peoples to be able to participate in the sustainability and sustainable energy debates. Thus, educational institutions and infrastructure need to be strengthened in both developing and developed countries.

Inter- and Multi-Disciplinary Education. To build a sustainable energy system and a sustainable world, general education must become dramatically more interdisciplinary, integrative, connective and comprehensive, and the topics of environment and energy needs to be incorporated in all aspects of education. In particular, scholarship and exchange programs need to be established to give talented individuals in developing countries multidisciplinary training in the field of sustainable energy.

Information Institutions and Infrastructure. To develop the global sustainable energy network described above, institutions and infrastructure related to information technology and information processing need to be strengthened, especially in developing countries.

Technology Transfer. The transfer of technologies to increase energy (and economic) efficiency, reduce pollution and other environmental impacts, and generally support sustainable economic development has been touted as one way that industrialized and developing countries, working together, can address imperfections in global energy markets. Technology transfer would presumably be funded in some way by industrialized countries. Martin Bell, however, has pointed out that simply transferring technologies (hardware) is not enough.[16] In addition to the knowledge of how to build and operate technologies, technology transfer should also provide the background knowledge, training and organizational structure that will allow local personnel to learn about, work with, adapt and upgrade technologies to better fit local conditions, and to press worthwhile technologies into broader local use. Without this process of internalizing both technological ?know-how? and ?know-why?, technology transfer is unlikely to reach its full potential in developing countries.

Foreign Aid. An integrated approach to overseas development assistance is imperative to the sustainable energy vision. There have been suggestions, for instance, of replacing the U.S. Agency for International Development with a Sustainable Development Cooperation Agency.[17] Carrying out the objective of an integrated approach to sustainable energy related ODA will place heavy demands on knowledge generation, dissemination and application activities.

International Regulation. The trick with international environmental regulations, as with national and sub-national regulation, is to provide overall sustainability (for example, ecological) guidance which is then used as the framework under which market forces are allowed to operate. We are fast moving into an era of increased international *environmental* regulation, although other sustainability areas tend to lag. International regulation is on the one hand an admission that maintenance of social and ecological sustainability at sub-international levels has failed; but on the other hand is an expression of increased global trade. In the environmental area, discussions are underway both on how to outright protect the environment (for example, binding targets and timetables under the Climate Change Convention) and on how to structure global trade so that environmental standards are similar in all countries (for example, establishment of the ?ISO 14000? environmental certification process).Other areas will attract increasing international regulation over time, areas such as the watchdoging of corporate practices in remote areas, or global trust-busting. International, and sub-international, regulation places a premium on accurate information and integrated knowledge.

National Income Accounts. The typical statistics on gross national product (GNP), gross domestic product (GDP), as well as other macroeconomic parameters that are often used to benchmark the health and wealth of an economy, do not usually measure changes in the human and environmental resource base upon which an economy is built. This deficiency can, for example, give the impression that a nation?s economy is growing at a healthy rate, when in fact that economic growth is built largely upon depletion of human and environmental resources, or can give the impression that an economy is growing slowly when in fact it is successfully pursing socially- and environmentally-sustainable development. ?The introduction of indicators and appropriate revision of national accounting systems may be all that is required to correct public-sector economic decisions in the long term, given the dominant focus of most governments on managing economic growth.?[18] The creation of ?green? national income accounts is premised on creation of substantial quantities of sustainability knowledge such as sustainability indicators and baseline information.

Sustainability Interventions in Energy Market. A wide range of government interventions in the market affects sustainability in the Energy Market. These include pricing and marketing policies (for example, energy subsidies favoring large supply projects), tax and fiscal incentives (for example, tax concessions to multinational companies for energy exploration), and exchange-rate and trade-protection policies (for example, trade policies that discriminate against forest products grown in a sustainable manner). Sustainability knowledge needs to be employed by governance institutions to, for example, eliminate energy supply subsidies, target energy performance (as in the U.S. Environmental Protection Agency?s Energy Star Program), promote comprehensive energy service delivery (as in California?s recent experiment with deregulation of the electric utility industry), and make capital available for energy efficiency investments

Full-Cost Pricing. The most important sustainability incentive in the energy sector is signaled through market prices. Full-Cost pricing is the principle that producers must bear the full cost of all social and environmental damage incurred in producing and delivering a product above some minimum threshold. ?Implementing the full cost principle would end the implicit subsidy that all polluting activities have received since the beginning of time.?[19] Full-cost pricing is similar to the ?polluter pays principle?. The full-cost principle in the energy sector, as in other sectors, is knowledge intensive. It demands that social and environmental costs of energy-related activities be made explicit, and that inappropriate subsidies are eliminated. The principle implies the imposition of ?green? taxes.

?Sustainability? Taxes. Even correcting unsustainable distortions in the Energy Market cannot take into account all external costs associated with energy production, transmission and use. One way to correct prices is through ?sustainability? taxes. Numerous taxes have been proposed and/or implemented. These include sulfur dioxide taxes, carbon dioxide taxes, various other emission taxes, and taxes related to energy consumption levels. Emission taxes, for instance, force all polluters to face the same per unit tax on emissions and if effectively employed can result in a cost effective (and possibly even efficient) allocation of pollution control responsibility. This can not be attained with the traditional command-and-control approach to regulation. A disadvantage of such taxes is that they put a financial burden on some firms and makes them uncompetitive. Similar to sustainability taxes are transferable permits or quotas schemes such as in the sulfur dioxide emissions trading system enacted under the 1990 U.S. Clean Air Act. All such tax and tax-related schemes demand high levels of information and knowledge activity.

Energy Planning and Energy Marketing. Energy planning is a tool to coordination production and consumption of energy. There must be a balance between free operation of markets and planning in the energy sector, and sustainability needs to become the by-word in energy planning. One example of a sustainable energy-oriented planning tool is Integrated Resource Planning (IRP). It goes without saying that knowledge generation and application plays a major role in such planning. Information on national and sub-national patterns of energy supply and demand, energy resources and reserves, and technical and operating information on existing energy infrastructure available in a transparent, consistent format helps to identify opportunities for improvement of energy market operation.

Sustainability Information for the Producer. An promising approach for fusing economic efficiency with sustainability is product life-cycle accounting. Basically, this approach involves scrutinizing all production processes in an integrated fashion so as to identify opportunities to minimize wastes of energy and material, and in the process cut costs and pollutant emissions. Several national and multinational agencies have programs to develop and encourage these sorts of economic/environmental ?cradle to grave? accounting practices in industry. Needless to say, such accounting requires intense collection and organization of information.

Sustainability Information for the Large Consumer. Information on the technical (for example, efficiency), environmental (for example, pollutant emissions), and economic performance (for example, capital and operating costs) of candidate energy technologies can help decisionmakers in large organizations choose which energy supply options are suitable from an environmental perspective. These types of data are available from equipment suppliers, regulatory agencies, and other non-governmental and institutional groups. Key issues in providing and using these data include how to make provision for data management and updating (as well as compilation), what level of detail to provide to provide optimum usability for particular audiences, data ?truthing? (making sure, for example, that manufacturers? claims are not exaggerated), and making sure that potential users are aware of the information resource.

Sustainability Information for the Small Consumer. Demand-side information to energy consumers (individuals, households, firms, and institutions) must be provided in order to make environmentally- sustainable choices. Only if energy consumers have adequate information as to the social and environmental ramifications of their choices on fuels and energy-using devices can the promise of market efficiency be fulfilled. Examples of ways to provide environmental information to consumers include: ecolabeling, ?green pricing? of renewable electricity (a market-based technique for proving consumers with environmental information on electricity bills as to what fraction of the electricity generated by the seller has been generate from renewable resources), and information of the energy/environmental performance of a product such a in energy consumption rating systems for a given appliance. In addition to the above type of information, consumers need on funding for purchasing energy sustainability-friendly products. Understanding and processing of the above types of sustainability information demands a high level of consumer education.

Energy Security. National energy security is increasingly tied to the global Energy Market. Although the term ?energy security? has no precise definition, it is often functionally thought of as the degree to which a country is self-sufficient in energy supply, insulated from disruptions in energy supply, and/or flexible in switching between different energy supply options.[20] As countries become increasingly reliant on global markets to supply fuels and energy infrastructure, energy security can either be enhanced or reduced. Energy security may be enhanced as open markets make countries economically interdependent, because nations may go to greater lengths to avoid political or military conflicts that could have repercussions on their economies It may be reduced when dependence on fuel and/or technology imports render a country less able, in the event of a political, military or economic crisis, to supply its own energy sector. Enhancing energy security is associated with tremendous information demands. For example, international information sharing is generally associated with increased transparency. Transparency is generally associated with increased trust, which in turn is generally associated with increased security, but, as can readily be imagined, the more nations in such a process the greater the information that must be coordinated.

Solar Society. The surest way to head in the sustainable energy direction is for society to commit itself to the long-term objective of establishing a global energy system based on solar-derived (or renewable) energy sources. The goal of a solar society can be seen as a refinement of the sustainable energy vision. Thus, one subset of sustainable energy knowledge is solar society knowledge. The market can be used to expand the use of renewables through R&D, demonstration projects, and technology transfer to lower-income countries, but at this point in time it needs a push from the public sector.

Energy Efficiency. Energy efficiency?which allows the same energy services to be provided with less fuel use?must be made the cutting edge of all sustainable energy policies. Energy efficiency measures apply to all stages of production and consumption of energy, and include replacing or refurbishing existing equipment such as giant turbines or home windows, constructing new equipment or appliances which are of higher than standard efficiency, reducing waste in manufacturing, and employing more effective ways of providing energy services (such as mass transit systems over personal automobiles). Energy efficiency knowledge is another subset of sustainable energy knowledge.

?Buddhist Energy Use?. A final incarnation of sustainability knowledge is what may be called an application of *no-knowledge*. ?Buddhist energy use? is merely a colorful way to denote the minimization of energy use by eliminating desires that drive up unnecessary consumption of energy. (Voluntary simplicity in energy use is another phrasing.) The term ?Buddhist? is used because one of the central tenets of Buddhism, as stated in the Four Noble Truths, is that the way to eliminate suffering (and energy use) is to eliminate the desires which lead to the suffering (or energy use). Buddhist energy use is premised not on ?addition? of knowledge but the ?subtraction? of knowledge. Although minimization of energy use by minimizing desires may seem remote from market operations, techniques for reducing unnecessary desires could be viewed as an energy service, and such could be touted in one manner or another in energy service companies advertising.

6. Conclusion

Energy, environment, and markets. The thread that can tie all these components together in the fabric of civilization in the 21st century is the vision of sustainability and its actualization through knowledge. A focus on knowledge is a focus on the foundation of the free market economic system. The authors envision the generation, dissemination and application of sustainable energy knowledge a fundamental tool for addressing rapidly approaching energy dilemmas in both developed and developing countries, and for addressing these energy dilemmas in the context of a highly complex, interdependent and synergistically dynamic Energy Market. A basic conclusion that can be drawn from this paper is that there must a substantially greater effort in the energy sector to consciously design global knowledge systems related to sustainability. The goal of such systems (of knowledge generation, dissemination and application) is to realize the vision of sustainable energy by harnessing the power of the market. They must be designed so that a modicum of consensus for action on energy sustainability can be obtained, and so that as broad a segment of the world?s population as possible is made participant in the consensus process. It has been suggested that the internet and modern information technology may encourage this process. Comprehensively designed knowledge systems and their integration into energy markets will create ?knowledgeable (energy) markets?. The watchword of knowledgeable markets will be sustainability, not blind growth.

ENDNOTES

ıe strong relationship between economic growth and energy use in both developed and developing countries is shown by the almost linear ionship between 1960 and 1990 in growth of worldwide electricity use and total global GNP; see Starr (1993).

ıe exajoule is equal to 10^{18} joules, or one billion gigajoules.- An exajoule is the equivalent of approximately 164 million barrels of oil equivaler ıillion tonnes of oil equivalent, or 34 million tonnes of coal equivalent~~, or 164 million barrels of oil equivalent~~.

ıese data are from British Petroleum Co. (BP) statistics (spreadsheet file ?fuelcons.wks?).- In this compilation we convert nuclear electricity ration to primary energy based on a direct conversion of electricity output to energy units, which is consistent with the treatment of hydroelect gy but is different than the method used by BP.

SDOE/EIA (1997).

owth of energy use in developing regions is even more robust?4.6 percent per year from 1995 to 2015?in the USDOE/EIA?s ?High Economic vth? scenario.

e, for instance, IPCC (1992) and Fujime (1996).

ıe World Commission on Environment and Development (WCED) defined sustainability (or sustainable development) as: ?development that s the needs of the present without compromising the ability of future generations to meet their own needs? (WCED (1987), p. 43). That ainability is virtually impossible to define is demonstrated in one search of sustainable development definitions which produced a list of 61; see ey (1989).

r example, see Lovins (1977).

r example, see Goldemberg et al. (1987).

Iany excellent works discuss the major environmental impacts of energy use; see for example Ehrlich et al. (1977), Lazarus et al. (??), and IPC 6a,b,c).

ayek (1945), p. 520.

olanyi (1957 [first published in 1944]).

should be noted that science was first used as an arbiter of human health criteria, and that its role in determining ecological health is more rec first pollution standards were in large part based on medical evidence.

ee, for instance, Haas (1992, 1997), and Wilkening (submitted for publication).

dvocates of the basic human needs approach include Ghai et al. (1977) and Streeten et al. (1981). In the area of energy and basic human needs group of prominent advocates is Goldemberg et al. (1987).

s related in Hayes (1993).

ee WRI (1993).

IacNeill, et al. (1991), p. 45.

ietenberg (1991), p. 214.

collaborative project (called the Pacific-Asia Regional Energy Security, or PARES, project) is currently being undertaken by the authors and rs in the United States and ~~in~~ Japan with funding from the W. Alton Jones Foundation. The PARES project is designed to address the issue of gy security and its domestic and international ramifications for future energy policy in the Asia-Pacific region.

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Figure 1a and b: 1995 World Energy Use by Fuel and Region/Subregion[1]

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[1] ***Source: British Petroleum statistics, spreadsheet file ?fuelcons.wks? . .Here Nuclear energy is counted as electricity output, not heat input; ?C&S Amer.? (Central and South America) includes Mexico; ?JANZ? is Japan, Australia, and New Zealand; and ?Other Asia? is all of Asia except China and Japan.***

Table 1: World Energy Use Trends, 1985 to 1995

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***Table 2: USDOE/EIA Projections of World Energy Use, 1995 to 2015*[2]**

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[2] ***Source: United States Department of Energy, Energy Information Administration (USDOE/EIA, 1997), <u>International Energy Outlook, 1997</u>. Report No. DOE/EIA-0484(97), April, 1997. ~~.~~ USDOE, Washington, DC, USA. ~~.~~ Figures for nuclear and ? Other? (mostly hydroelectric) fuel use were modified to reflect electricity output. ~~.~~ Note that the USDOE/EIA energy consumption figures for 1995 are somewhat different from those published by British Petroleum? probably due to the use of different accounting practices.***