ENERGY PLANNING AND POLICIES FOR SUSTAINABLE DEVELOPMENT: TOWARD A NEW PARADIGM

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Summary

At the dawn of the 21st century, a new energy paradigm, forged by technological advances, resource and environmental constraints and socioeconomic demands, has begun to emerge. This paradigm is based not on a finite stock of fossil fuels, but on a virtually limitless flow of renewable energy—sun, wind, water, wood, the earth's heat—and on the most abundant element in the universe: hydrogen. Whereas today's dominant energy model is centralized, large-scale and focused on increasing supply, its successor will be decentralized, downsized and directed toward meeting demand. The energy system, in other words, is undergoing a sort of *glasnost* and *perestroika* similar to that seen in the economic and political systems of the former Soviet Union a decade ago. Now as then, the broader implications of this upheaval are likely to be nothing less than revolutionary.

This energy paradigm shift may have particularly dramatic repercussions for today's

international system. The new model has the potential to lessen security threats that are both familiar and new, such as dependence on imported oil and climate destabilization. Such a paradigm may be especially welcome in the developing world, where 4 billion people have been underserved or entirely bypassed by the conventional energy system. The structure will create new economic and political rewards, transforming the roles of government and industry in the energy sector. It is likely to broaden the geopolitics of energy and energy policy, traditionally preoccupied with resource conflict, to include the new dynamic of environmental cooperation and sustainable development

1. Introduction

An intimate relationship between energy and international politics has developed during the last two hundred years. The 18th century rise of the British Empire was fueled by the Industrial Revolution, which was in turn powered—and to some degree symbolized—by the heavy use of coal. Modern Germany's late-19th century industrial expansion and its subsequent imperial aspirations were likewise supplied and characterized by massive coal consumption. The 20th century has been labeled "the age of oil," which laid the foundation for unprecedented economic growth in the United States. Access to petroleum has factored into many of the modern era's international conflicts, including the Japanese attack on Pearl Harbor in 1941 and the Persian Gulf war in 1991, and has shaped the geopolitics between and among western economies, the Middle East and the developing world. At the dawn of the 21st century, however, a new energy paradigm, forged by technological advances, resource and environmental constraints and socioeconomic demands, has begun to emerge.

This paradigm is based not on a finite stock of fossil fuels, but on a virtually limitless flow of renewable energy—sun, wind, water, wood, the earth's heat—and on the most abundant element in the universe: hydrogen. Whereas today's dominant energy model is centralized, large-scale and focused on increasing supply, its successor will be decentralized, downsized and directed toward meeting demand. The energy system, in other words, is undergoing a sort of *glasnost* and *perestroika* similar to that seen in the economic and political systems of the former Soviet Union a decade ago. Now as then, the broader implications of this upheaval are likely to be nothing less than revolutionary. This energy paradigm shift may have particularly dramatic repercussions for today's international system. The new model has the potential to lessen security threats that are both familiar and new, such as dependence on imported oil and climate destabilization. Such a paradigm may be especially welcome in the developing world, where 4 billion people have been underserved or entirely bypassed by the conventional energy system.

The structure will create new economic and political rewards, transforming the roles of government and industry in the energy sector. It is likely to broaden the geopolitics of energy, and of energy planning and policy, traditionally preoccupied with resource conflict, to include the new dynamic of environmental cooperation and sustainable development. Radical as this worldview may seem relative to traditional views on energy, it has found its way into the speeches of major oil company leaders. In a remarkable message delivered in Houston, the capital of the American petroleum industry, Michael Bowlin, then chairman and CEO of ARCO, announced to fellow executives in February 1999, "We've embarked on the beginning of the Last Days of the Age of Oil…Conditions are converging for another sea change in the energy use mix—along the spectrum away from carbon and headed toward hydrogen and other forms of energy."

Bowlin concluded with a challenge to fellow oil executives that applies equally to nation-states: "Embrace the future and recognize the growing demand for a wide array of fuels; or ignore reality and slowly but surely be left behind." Like the hydrocarbon era that precedes it, the dawning solar-hydrogen age carries its own set of risks and opportunities, as well as its own set of winners and losers. Nations that anticipate and position themselves for the transition are likely to reap an array of social, economic and environmental benefits. Those who remain mired in the status quo will only prolong the fossil-fuel legacy of ecological instability and political insecurity, leaving them less prepared to face the challenges of the new millennium.

2. Resource Limits and Ecological Constraints

Technological change alone cannot account for the emergence of the new energy paradigm. Past transitions—from wood to coal, from coal to oil—have also been influenced by a volatile mix of forces, including resource limitations and environmental and socioeconomic issues. America's oil-based economy developed from new technologies, the discovery of plentiful oil, the desire for cleaner alternatives to horse-drawn carriages and the popularity of gas-lighting. Similar forces exist today, though their relative importance has changed in significant ways.

2.1 Resource Limits

Resource limits could help push the world away from fossil fuels in coming decades. Oil is the leading energy source today, with a 34 percent share of commercial use; natural gas has emerged as an environmentally-preferred alternative for many uses, and accounts for 23 percent; coal has retained a grip on power generation, and holds a 22 percent share. While reserves of natural gas and coal are believed sufficient to last past the 21st century, those of oil are not. In much the same way that 17th century Britain ran out of cheap wood, today's concerns center on the possibility of running out of inexpensive petroleum.

While the size of the remaining oil resource is hardly a new issue, the latest wave of worry has been led by geologists from the oil industry itself. Geologists Colin Campbell and Jean Laherrere estimate that roughly 1 trillion barrels of oil—little more than half the original resource—remain to be extracted. Extrapolating their figures results in a projected peak (and subsequent reduction) in world production by the year 2010; applying more optimistic resource estimates from other oil experts prolongs the peak by only a decade. A peak in world oil production early in the next century raises issues for prospective new consumers.

The problem is less the large amount of oil currently used—67 million barrels daily—than the intent of many developing countries, most lacking sizable indigenous supplies, to increase their use of oil for automobiles and trucks. Even if industrial-country oil use were to plateau, meeting the growing needs of China, India and the rest of the developing world along the petroleum-heavy path of the industrial world would require a tripling of world oil production by 2020—a point at which production may well be declining.

2.2 Ecological Constraints

Ecological constraints, however, are likely to influence the evolution of the new system more than resource limits. Fossil-fuel burning is a leading source of air pollution and a leading cause of water and land degradation. Combustion of coal and oil produces carbon monoxide and tiny particles that are associated with lung cancer and other respiratory problems; nitrogen and sulfur oxides form urban smog, bringing acid rain that damages forests, bodies of water and historic buildings. Water quality is impaired by the toxins released in oil spills, refinery operations and coal mining. More and more, oil exploration disrupts fragile ecosystems and coal mining removes entire mountains. Although in recent decades modern pollution controls have improved air quality in most industrial countries, the deadly experiences of London's 1952 "fog" that killed 4,000 risks being repeated in Mexico City, São Paulo, New Delhi, Bangkok and many other cities in the developing world. Each year, for example, coal burning contributes to an estimated 178,000 premature deaths in China's cities. Beyond these local and regional problems lie the cumulative, global environmental threats that undermine the long-term sustainability of the current energy system.

More than 200 years after we began burning the sequestered sunlight of fossilized plants that took millions of years to accumulate, scientists have discovered that the carbon those fuels produce is disrupting the Earth's energy balance, causing the planet to warm. Fossil fuel combustion has increased atmospheric concentrations of carbon dioxide (CO_2) by more than 32 percent since pre-industrial times. CO_2 levels are now at their highest point in 160,000 years, and global temperatures at their highest in at least 1,200 years. Climatologists have determined that these human activities have ended the period of relative stability in the atmosphere that has endured over the last 10,000 years, and which has permitted the rise of agricultural and industrial society. The U.N.-appointed Intergovernmental Panel on Climate Change (IPCC) has concluded that "The balance of evidence suggests a discernible human influence on global climate." The IPCC has also agreed that the planet has warmed by 0.6 degrees Celsius since the late 19th century.

Should current emissions trends continue, global temperatures will increase by another 1.4 to 5.8 degrees Celsius during the 21st century. A broad range of social, economic and environmental dislocations are projected to result from this warming. These include, but are not limited to, rising sea levels and reduced coastal areas; an increase in the frequency and intensity of extreme weather events; a greater incidence and range of infectious diseases; an overall reduction in the productivity of agriculture and forest systems, and freshwater availability; and the forced redistribution and loss of temperature-sensitive species.

Climate change is anticipated to become a major additional stress on a number of existing environmental pressures already confronting the human species—from water shortages to land degradation to air pollution. While developing countries—particularly sub-Saharan Africa and low-lying small island states—will by virtue of economic situation and geography be hit hardest, many regions in the industrial world, from the U.S. Midwest to the United Kingdom to Australia, are also vulnerable to severe and potentially irreversible impacts.

Signs of a warming world—retreating ice shelves, receding glaciers, dying coral reefs, migrating and disappearing plants and animals—are virtually ubiquitous. A "business-as-usual" climate model by the British Hadley Centre for Climate Prediction and Research predicts that by 2050 there will be a 90 million ton shortfall of food, placing an additional 30 million people—mostly in Africa—at risk of starvation.

The model predicts that 66 million more people will face water stress and that 20 million more will be at risk of flooding. The proportion of world population at risk of malaria will also increase—mainly in areas currently free of the disease.

The Hadley scenario also projects a significant decline in tropical forests and the desertification of tropical grasslands, creating a positive feedback as this vegetation loss releases additional carbon to the atmosphere. Accelerating climatic change increases the likelihood of "surprises" like these.

Once thought to be "linear," the climate is now thought of as a chaotic system that can switch abruptly to another equilibrium after crossing a temperature threshold. Previous dramatic changes in climate have coincided with the collapse of ancient civilizations in the Americas, Europe and Africa.

Past events for which scientists have evidence and which may recur in a rapidly changing climate include the shutdown of the ocean's heat-carrying conveyor belt, which once gave Dublin the climate of chilly Spitsbergen, Norway, nearly 1,000 miles north of the Arctic Circle; and "megadroughts" in mid-continental North America that at one time dried up the region's agricultural breadbasket.

Debate also surrounds the potential instability of the West Antarctic ice sheet, whose collapse could raise sea levels by four to six meters, causing major flooding worldwide. While such an irreversible event may not take place during the next century, rising greenhouse gas concentrations over this period raise the odds of it occurring at a later date.

The best scientific estimates suggest that stabilizing atmospheric CO_2 concentrations at safe levels will require a 60 to 80 percent cut in carbon emissions from current levels over the next century.

While the global energy system has been "decarbonizing" over the last two hundred years, moving to less carbon-intensive fuels and improving energy efficiency, the rate of change will need to accelerate significantly to meet this objective. Though a very small step on a long journey, the 1997 Kyoto Protocol to the U.N. Framework Convention on Climate Change may be moving us toward the eventual end of the fossil fuel-based economy.

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Biographical Sketch

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