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# Beyond Pollution and Risk: Energy and Environmental Policy in the Greenhouse

by

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## Introduction

World oil prices have climbed to start the new century and retail products like gasoline have become 20-25 % more expensive. Voices of concern are once again being raised about the global energy system. While there are important impacts from costlier energy, especially on less well-off members of society, our aim cannot be the restoration of "cheap energy." Neither our planet, which is now feeling the early effects of climate change, nor our public health – it is estimated that two-thirds of the world's urban populations breathe unhealthy air, thanks to energy-based pollution (Figure 1) – can endure cheap energy for much longer. Instead, our global response needs to focus on the requirements of an environmentally sustainable and socially equitable energy future.

The current energy system will not last more than two decades into the new century. Significant changes to its architecture are inevitable due to mounting problems of pollution and risk. The meeting of the world's nations in the Hague (Netherlands) in November of this year will be watched for the signal it sends of our willingness to act on behalf of our grandchildren's future. Will we send forward to them a legacy of energy inefficiency and waste? Or will we recognize that the current energy regime is simply a form of subsidy to the present generation at the expense of future generations, and instead take the necessary actions to halt global warming by building a new and sustainable energy regime? Relatedly, will we continue to subsidize energy technologies, such as nuclear power, that are unable to compete in open markets but impose significant risks to a peaceful future? Or will we take the needed actions to develop the new energy economy (Flavin, 2000) and the new patterns of human settlement (Droege, 2000) that rely on renewable energy and distributed power architectures? These are the key questions for our energy and environmental future.

## The Challenge of Global Warming and East Asia

According to the UN-sponsored Intergovernmental Panel on Climate Change (IPCC), human activities, especially over the past 100 years, have already triggered a planetary warming process (IPCC, 1996a). Most of the warming identified by the IPCC has occurred in the 20th century with the last 15 years being the warmest on record. The rate of warming in this century is greater than any in the past 10,000 years. In excess of 22 billion tons of greenhouse gases (by molecular weight) are annually released by human activity. It should come as no surprise that annual releases of billions of tons of greenhouse gases are affecting the thin layer

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of atmosphere in which the earth's climate is determined. In fact, as Table 1 summarizes, the basic chemistry of the atmosphere has changed as a consequence of industrial development. In the words of climatologist Nicholas Shackleton, the impacts of anthropocentric emissions of GHGs on atmospheric chemistry have taken us "outside what nature has experienced in the recent past 500,000 years" (*New York Times*, January 16, 1990).

This is not merely a physical concern, but a social and economic one as well. If the warming trend continues throughout the 21st century, average global surface temperatures will increase by 2-4°C and sea levels will rise by 45-90 cm (IPCC, 1996b). Such changes in climate are projected to cause an increase in storms, droughts, fires, and pest outbreaks. World agricultural and fisheries productivity would be threatened. Infectious diseases such as malaria, dengue, yellow fever, viral encephalitis, salmonellosis and cholera may spread as a result of climate-induced effects on local ecologies. And coastal cities and islands will be at increased risk of flooding and inundation.

As a region, East Asia has much at stake in the international climate negotiations. The outcome of the policy debate could greatly affect the economic and environmental future of the area. In the past two decades, East Asian economic growth has outpaced that of any other region in the world. While the world economy grew, on a per capita basis, at an inflation-adjusted rate of 0.8% during 1980-95, Asia[2] averaged 3.2% per year. The East Asian economies of China, Korea and Taiwan experienced the highest rates of growth, recording average annual per capita growth rates of 8.3%, 7.7% and 6.7%, respectively (Figure 2). To fuel the region's economic expansion, Asian countries dramatically increased their use of conventional energy. In contrast to a *negative* per capita average annual growth rate in energy consumption of -0.3% for the world, conventional energy use in Asia climbed yearly by more than 2.2% per person during 1980-95. Again, East Asia recorded the most rapid growth with Korea and Taiwan increasing annual per capita energy consumption by 9.5% and 5.9%, respectively. Even Japan recorded above-average growth in its per capita energy use.

Because the build-up of GHGs in the atmosphere is largely traceable to fossil fuel combustion,[3] international negotiations will focus on basic changes in energy systems. East Asia's dependence on fossil fuel to spur its economic expansion means that negotiated targets for $CO_2$ reductions will pose special challenges for the region. China, Korea and Taiwan will face pressures to reduce the energy intensity of their development. Even though Japan is a world leader in industrial energy efficiency, it is the fourth largest source of GHG emissions and will be expected to shoulder the initial burden (with North America, Europe, Australia, and New Zealand) of reducing global emissions. In sum, the challenge of redirection in energy-development relationships along a climate-stable, environmentally sustainable path is central to East Asia's future.

**Climate Change and Island Sustainability: Who is at Risk?**

Island societies have high stakes in the risk of global climate change and the international regime that is evolving to address this risk. In particular, they are vulnerable to the

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[2] Excludes central Asian countries which were part of the former Soviet Union.

[3] Social activities involving fossil energy production account for nearly 60 percent of worldwide greenhouse gas emission (Byrne et al, 1994).

impacts of climate change, including sea level rise, increased storm activity, and salt water intrusion. As a result, islands have been active in the international discourse and debate on the issue from the outset, and have vigorously urged action that would avoid further risks climate change by significantly reducing so-called greenhouse gas emissions.[4]

Climate change and sea level rise pose perhaps the greatest potential threat to small islands. The IPCC (1996a) has concluded that the mean surface temperatures of the earth have risen between 0.3$^{o}$C and 0.6$^{o}$C since the late nineteenth century. Global mean sea level has risen by 10-25 cm over the solar period and is projected by the IPCC to rise by13-94 cm under the most climate-sensitive scenarios, and by 20-86 cm using the IS92a scenario,[5] by the year 2100 (IPCC, 1996a). Taking into account future changes in aerosol amounts under the 1992a scenario, sea levels could rise by 20 cm by the year 2050 (IPCC, 1996a). Figure 3 depicts the IPCC IS92 scenarios for projected sea level rise and their impacts on selected coasts and islands worldwide, as well as sea level rise resulting from stabilization of $CO_2$ emissions at 450 parts per million (ppm). At a 20 cm rise,18 million additional people worldwide will experience yearly storm surges, and at an 80 cm rise in sea level, 65% of the Marshall islands and Kiribati will be inundated. It is estimated that a 100 cm rise in sea level could inundate 70 percent of the land mass of the Seychelles (UN/DPI, 1999). The implications for coastal land loss under these scenarios are severe.

For islands, coastal land loss or damage raises a host of concerns. Island populations are concentrated along coastal zones. Their tourism industries are typically coastally based, and likewise most of the tourism infrastructure is concentrated in the coastal zone. For example, the majority of Caribbean tourism facilities are concentrated within 800 meters of high water mark (Bloomestein et al, 1996). In Jamaica, 60 percent of tourist accommodation units are less than 15 meters from the high water mark. These factors, along with the coastal concentration of industrial infrastructure, dependence on fisheries and other coastal and marine resources, the potential loss of marine resources which island countries have yet to develop, the potential loss of agricultural land and other impacts related to salt water intrusion, are all likely to have severe economic, social and cultural repercussions for island communities. The looming possibility of more frequent and more intense hurricanes further exacerbates the problem. Table 2 summarizes the impacts that small islands will face as a result of sea level rise, compiled from empirical studies in the literature.

### Nuclear Power: A Costly and Risky Choice

Some will argue that the prospect of global warming provides a strong case for restarting worldwide development of nuclear power. Advocates of the nuclear option will stress that it is the least disruptive and most cost-effective alternative. In Japan, Korea, Taiwan, and in many other parts of Asia, this argument is strongly asserted. But efforts to rehabilitate nuclear power in response to the threat of climate change are deeply mistaken.

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[4] The principal greenhouse gases (GHGs) are: carbon dioxide ($CO_2$), methane ($CH_4$), ozone ($CO_3$), nitrous oxide ($N_2O$), sulfur dioxide ($SO_2$) and chlorofluorocarbons (CFCs). Among these, $CO_2$ is the most significant by volume.

[5] The IS92a is the emission scenario most comparable to the IPCC (1990) Scenario A, the so-called *business-as-usual* (BAU) scenario.

First, revitalizing nuclear power is not a cost-effective response to global warming. Keepin and Kats (1988) and Flavin (1990 and 1996) have shown through comparative analyses of nuclear power, energy efficiency and renewables as GHG abatement strategies, that nuclear is, by far, the economically inferior option. In fact, Keepin and Kats found that each dollar invested in energy efficiency in the U.S. electricity system displaced nearly seven times as much $CO_2$ as did a dollar invested in nuclear power. They concluded that even under the most optimistic assumptions about the future economics of nuclear power, efficiency would still displace between 2.5 and 10 times more $CO_2$ per unit of investment. In addition, Hohmeyer (1992) has demonstrated that after a full accounting is made of the environmental and social costs of energy production, nuclear power is far more costly economically, environmentally and socially than the benign sources of solar and wind energy. With respect to greenhouse gas reduction, then, nuclear power is much too expensive to be seriously considered.

Second, nuclear power presents a pervasive danger, in the form of nuclear accidents, that is a no less fundamental threat to our society and environment than global warming. Just one month after *The Economist*, a British business magazine, had declared in its lead article on "The Charm of Nuclear Energy" that the technology was "as safe as a chocolate factory" (March 29, 1986), the lid blew off No. 4 Reactor at Chernobyl. The explosion released the largest quantity of radioactive material ever in one technological accident. The estimated 28 megacuries of escaping radioactive material posed an immediate threat to the lives of 130,000 people within a 30 kilometer radius who had to be evacuated, and 300-400 million people in 15 nations were put at risk of increased radiation exposure. Forecasts of additional cancer deaths attributable to the Chernobyl accident range have ranged from 5,000 to 75,000 (Byrne and Hoffman, 1988).

But, the most tragic consequence of playing the "nuclear card" to avert global warming is the likely exclusion of genuinely peaceful and ecologically benign options from our energy future. As Amory Lovins pointed out 20 years ago (1977), society cannot simultaneously choose so-called "hard path" technologies such as nuclear power and "soft path" options of energy conservation and renewable energy. The two paths are mutually exclusive and contradictory — one cannot, on the one hand, pursue the policy, economics and technics of large-scale, centralized energy supply systems in which ever-increasing consumption is necessary to keep such systems solvent and, on the other hand, advocate the policy, economic, technological, and ecological values of a decentralized, moderate-scale energy system where *less* energy consumption is essential to its success. A $ 2-3 billion investment in a nuclear power plant — the cost of the typical nuclear electricity facility — cannot be put at risk by vigorous efforts to save energy and to harness renewable sources such as wind, biomass, geothermal and solar energy. Society almost certainly must surrender soft path options in order to "rationalize" the use of nuclear energy; there is little choice on this score. The actual experience in Japan with the effects on $CO_2$ of increased use of nuclear power is instructive. In fact, after 20 years of steady increases in nuclear generation capacity, not only has Japan's $CO_2$ emissions failed to decline, they have actually increased (see Figure 4). It should be noted that nuclear power's share of Japanese energy supply increased during the period covered by Figure 4 (see Takagi, 1997.). Thus, nuclear power is not a solution to the $CO_2$ build-up; it is part of the problem.

Evaluated in these terms, the reduction in greenhouse gas emissions promised by nuclear power is hardly worth the immense risks it raises. The solution to this problem lies elsewhere, in the technologies and institutions of the soft path — modular, decentralized economic systems based on low-$CO_2$ emitting/low-materials using technologies.

## Policy Considerations for Island Developing Countries

The critical question for developing countries at this juncture is what can be done to maintain an international focus on long-term climate stability requirements that are key to the successful pursuit by islands of a sustainable development strategy? The fate of entire island nations are at risk and many island communities will be increasingly vulnerable to storm surges and sea level rise if the "go-slow" strategies of the Kyoto Protocol are the only actions industrialized countries are prepared to take. In effect, island nations will be sacrificed for cost-efficiency goals, if more aggressive action is not taken.

It seems clear that the first priority for islands must be to prevent further damage to their members and to lower their future risks from human-induced global climate change. In this vein, a new strategy for AOSIS to consider, that is consistent with these overarching goals, might be to advocate an international policy of penalty assessments on OECD countries until they reach an agreed upon sustainability condition (such as the 3.3 tons of $CO_2$ equivalent found in Byrne et al (1998a)). Given the high level of difficulty involved in reaching international agreements on climate change to date, such a policy would appear infeasible without the support of powerful allies. These may be available in blocs of developing countries now being courted by the OECD countries in hopes of trading for $CO_2$ reductions for new technology, i.e., China, India, Brazil, South Africa and others. A partnership between these countries and AOSIS may be possible since all have a common interest in spurring OECD countries to significantly reduce $CO_2$ emissions. Such a partnership could remove the opportunity for delaying strategies by wealthy nations if assessments were high enough to provide incentives for them to undertake significant investments in new, clean energy technologies. Assessments collected from the industrialized bloc could be deposited in a Sustainable Development Fund to be used by developing countries to acquire energy-efficient technology and to tap appropriate renewable energy options. Such a Fund would provide far more investment in a sustainable development path than the current Global Environmental Facility.

A second strategy is for island countries to join with others in supporting a global strategy to accelerate recent dematerialization trends in technology development. Such a strategy would encourage a worldwide transition to new technology platforms that rely on zero/low-polluting and zero/low resource-consuming production and processing. Recent advances in computing and communications hold out promise for a different economy-environment-society relationship that uses intelligence, rather than cheap resources, to meet human needs. Island development policies should focus on ways to obtain a share of the new markets and technologies built on greener energy systems and low-materials production and consumption. But the promise of such a future will depend greatly on new policy commitments that embody core commitments to equity and sustainability (Byrne and Lin, 1998b). Without commitments to these principles, the new economy will look all too familiar.

Three recent analyses envisioned a future that would promote equity and sustainability. One, released by Shell Oil International, has forecasted declines in fossil fuel use by the world economy starting in 2020-2030 (Figure 5). Even its business-as-usual “Sustained Growth” scenario, in which world energy consumption is expected to grow steadily, projects renewable energy as supplying nearly *all* of the growth in energy use after 2020. In its very important “Dematerialization” scenario, Shell recognizes that technology leadership is increasingly in the direction of lighter yet stronger materials (such as fiber optics and light-weight vehicles) and in the substitution of materials altogether with information (e.g., data highways and CAD). Under this scenario, the company sees an obsolescence of heavy industry, replaced by “technology systems requiring a much lower energy input” (Shell, 1996). The company has concluded that the dematerialization trends are inevitable and has begun to rethink its investment strategy. An oil ally, British Petroleum, has recently gone a step further, calling for international actions to go "beyond petroleum."

Shell Oil’s world forecast is matched in the U.S. by a 1997 report released by a consortium of energy research organizations headed by the American Council for an Energy-Efficient Economy (ACEEE). It builds upon an earlier study done with the American Gas Association (an umbrella business organization for the American natural gas industry). In its *Energy Innovations* report, ACEEE, et al also point to technology trends, which are replacing traditional industrial processes with low-energy and low-materials substitutes. In their forecast, the U.S. economy continues to grow at current rates but energy consumption actually *falls* 8% by 2030. The only energy source forecasted to grow in the first half of the next century is renewable energy. Similar to Shell Oil’s report, the analysis by ACEEE, et al expects almost all sectoral economic growth to occur in the high-technology fields with low materials consumption. If the U.S. follows the technology innovation path laid out in the report, $CO_2$ emissions are cut in half over 1990 levels by 2030 without harmful economic effects.

At the Kyoto climate change negotiations, a scientific team from Japan’s universities and research institutes unveiled a new vision of the national economy consistent with the reports by Shell and ACEEE, et al. Without a change in course in energy and industrial policy, the CASA report expects Japan’s $CO_2$ emissions to increase by 25% in 2010 over 1990 levels. The report then discusses the prospects for diffusing 91 high-efficiency technologies, which are *currently* cost-effective but face market entry and information barriers. When these barriers are removed, the world’s already most efficient economy is forecast to decrease its $CO_2$ emissions by 9% in 2010 (relative to 1990 levels); and it achieves this reduction while *improving* its performance (Table 3). Echoing the Shell report, the Japanese expert group then considers the impact of industrial restructuring, with the diffusion of the 91 high efficiency technologies, and concludes that the country’s $CO_2$ emissions can be cut by 21%, again while improving the economy’s performance.

These three studies share a common message: the world and national economies are shifting from energy- and materials-intensive development to one where renewable energy and energy efficiency are ascendant in the energy sector and where dematerialization trends in production diminish the demand for natural resources generally. The transition to a global economic base which favors low-polluting and low-energy intensive production and consumption offers island countries perhaps their greatest hope for a sustainable future.

Third, while island countries must continue to find suitable strategies within the context of the Conference of the Parties to the UNFCCC, they should consider non-traditional channels of action, specifically, greater collaboration with civil society efforts to grapple with the problem of climate change. It has already been observed that, due to their already low aggregate emissions levels, islands can have little impact on global GHG emissions. In addition, as mentioned previously, islands are already engaged in regional programmes for vulnerability assessment and other activities for adaptation to the impacts of climate change. What has not yet been explored is for island countries to join forces with global environmental movements and wider civil society efforts to address sustainable development concerns. International and regional environmental movements have formed that regularly articulate alternatives to the targets in the Kyoto protocol. These movements — Climate Action Network, Friends of the Earth, and others — are active in international trade and finance debates, as well as the full gamut of environmental issues and initiatives, to forge a sustainable and equitable future. Such organizations have the capacity to mobilize resources to advance their cause. Some pertinent questions worth exploring, therefore, are: to what extent have island communities been identified and brought into the broader education, awareness building and lobbying process? Can island communities gain access to resources and information through a strategy of partnership with non-governmental environmental organizations when common objectives exist? What can the politically active and resource endowed sections of global civil society do to raise awareness of the plight of island communities at risk and to put a "human face" on the problem of global warming? In essence, as island countries continue to battle in the international policy arena, can they add political strength to their strategy by drawing on forces traditionally outside the formal process? These questions are worth the consideration of civil movements in cooperation with islands as they evaluate next-stage actions in support of an agenda for sustainable development.

**Is a Sustainable and Peaceful Energy Future Feasible? — The Case of Korea**

Lest one doubt the "practicality" of such a future, a partnership of independent Korean and U.S. researchers has recently shown how a Korean energy future is available that requires dramatically less energy consumption than present trends and *improves* economic competitiveness, environmental quality and social equity. The Center for Energy and Environmental Policy (CEEP) of the University of Delaware has cooperated with the Environmental Planning Institute of Seoul National University, the Research Institute of Energy, Environment and Economy of Kyungpook National University, and the Citizens' Institute for Environmental Studies of the Korean Federation of Environmental Movements to create the Joint Institute for Sustainable Energy and Environmental Futures (JISEEF).

In a major publication, the JISEEF team offers a detailed analysis of Korea's energy efficiency and opportunities based on an examination of more than 2,500 currently available technologies (JISEEF, 2000). The *JISEEF I Scenario* shows how state-of-the-art energy services can be provided while costing Korean society much less in investment capital than the extravagant official plans of the national government. The Korean government intends to *expand* the use of large-scale, increasingly obsolete energy technologies to build a supply system that will be *twice* the size of the current infrastructure by 2020. To double the size of the national energy system, the government aims to build an unbelievable 22 new nuclear energy plants in twenty years. The *JISEEF I Scenario* demonstrates that not even one of these plants is needed if, instead, the society embraces a forward-looking technology and economic strategy built on "small-is-better" high-efficiency energy equipment and increased reliance on an information-based economy.

The JISEEF team estimates that full implementation of the *JISEEF I Scenario* will yield energy savings of 28% (i.e., a decrease of 86.4 MTOE) over official forecasts for 2020 and will cut $CO_2$ emissions by a similar rate (reducing national emissions by 52.7 MTC). The Major Policy Commitment Strategy identifies energy and $CO_2$ savings of nearly 19% (corresponding to a decrease in energy use of 58.0 MTOE (18.9%) and emissions of 34.5 MTC—see Table 4).[6]

An aim of the JISEEF project is to create for Korea an energy future that also contributes to climate stability. One standard under investigation by the JISEEF team is to encourage Korea to voluntarily seek to cap its emissions by 2020 at year 2000 levels. Measured by this yardstick, *JISEEF I* would help the country to make substantial progress toward meeting a year 2000 $CO_2$ cap. The JISEEF I Major Policy Commitment Strategy will cut in half expected $CO_2$ emissions, while removing the need to build any nuclear power plants. To realize an additional 36.0 MTC of $CO_2$ reductions necessary to meet a year 2000 $CO_2$ cap, the JISEEF team is investigating scenarios that promote renewable energy use, take advantage of materials recycling/reuse, invest in new technologies (notably, fuel cells) and embrace sustainable development planning strategies. Through these scenarios, JISEEF will offer practical pathways for creating sustainable and peaceful energy choices for South Korea's citizens.

Figures 6 contrasts Korea's projected primary energy consumption and $CO_2$ emissions in 2020 under the government's official forecast (MOCIE/KEEI, 1998) and the *JISEEF I Scenario*. The choice before Korea's citizens is made clear by these graphs. In one future, energy use and $CO_2$ emissions continue to rise rapidly, doubling the size of the energy regime and increasing $CO_2$ pollution by 60%. Such a future also expands the country's social and environmental vulnerabilities through a dramatic escalation in the use of nuclear power. This is the future that Korea's current energy managers offer. In the JISEEF alternative, citizens can choose a sustainable future in which energy consumption and $CO_2$ emissions reach plateaus by 2015 at levels that are one-third *less* than conventional policy now expects. This sustainable future dramatically reduces energy-based pollution, frees up economic capital to serve important social needs, protects national and global ecological resources, and offers citizens their first opportunity for democratic energy governance.

Assuming that the 1999 oil price of $18 per barrel would be maintained through 2020,[7] the JISEEF team estimates that the Major Policy Commitment Strategy of the *JISEEF I Scenario* would yield economic savings of 9.0 trillion won ($7.5 billion) for Korea in 2020. Environmental benefits in the form of $CO_2$ emission reductions from the *JISEEF I Scenario* are also significant. According to Edmonds et al (1999), reducing $CO_2$ emissions to 1990 levels will cost Japan $324 (1992$) per avoided ton of carbon in 2020 (assuming no emissions trading). The United States will have relatively lower marginal abatement costs ($170/TC) but will bear the largest total costs because of the large amount of carbon emissions to be avoided (Edmonds et al, 1999). Assuming a cost of $200 per avoided ton of carbon for South Korea,

[6] These figures depict two action scenarios: Full Implementation, which anticipates a national effort that captures all cost-effective energy efficiency measures identified by the JESEEF team; and Major Policy Commitment, which assumes that 65% of the cost-effective measures identified in JISEEF I are implemented.

[7] The official forecast of the Korean government adopts the 1999 oil price for its forecast. The JISEEF team did not alter this assumption. Recent increases in world oil prices underscore the conservative character of this assumption.

the Major Policy Commitment Strategy, with its *currently cost-effective* opportunities, would save 8.3 trillion won ($6.9 billion) for the South Korean economy by 2020. Combining the economic and environmental savings (9.0 trillion won plus 8.3 trillion won) of *JISEEF I's* Major Policy Commitment Strategy, societal savings of 17.3 trillion won ($14.4 billion) can be expected.

Figure 7 depicts the supply curve of avoided $CO_2$ emissions under *JISEEF I*. In this graph, the y-axis denotes the cost per avoided ton of carbon, and the x-axis denotes avoided carbon emissions. To calculate the unit cost of the avoided carbon emissions, the annual investment in each efficiency measure (for materials and labor) is divided by the annual carbon emissions avoided. Among the 24 aggregate measures displayed in Figure 7, commercial lighting is the least expensive measure to avoid $CO_2$ emissions in South Korea, while building shell technology improvements and electric buses are more expensive ones. The largest avoided $CO_2$ emissions in the *JISEEF I Scenario* derive from industrial cogeneration (7.6 MTC), followed by efficiency upgrades for industrial thermal systems (6.9 MTC), fuel efficiency gains for passenger cars (6.8 MTC), residential heating upgrades (5.1 MTC) and commercial lighting improvements (3.9 MTC).

The total marginal investment cost for these 24 measures amounts to 5.3 trillion won ($4.4 billion), and the avoided $CO_2$ emissions are 48.5 MTC, yielding a marginal cost of approximately 108 thousand won ($90) per avoided ton of carbon. To avoid 34.5 MTC under the Major Policy Commitment Strategy of the *JISEEF I Scenario* would cost 3.7 trillion won ($3.1 billion). Thus, the net benefits to the Korean economy would be 13.6 trillion won ($11.3 billion) in 2020 (economic and environmental benefits of $14.4 billion minus a marginal cost of $3.1 billion). This is probably a conservative estimate because the uncertainties associated with petroleum prices, $CO_2$ abatement costs and multiplier effects are likely to favor higher benefit values.

What will be lost by following the *JISEEF I* path? As far as one can tell, the only loss would be to the nuclear power industry. With no serious effort in international science and engineering underway to rescue this riskiest of technologies from its inevitable demise, it would appear that Korea in fact could gain from the phase-out of this industry. As surely as the PC and cell phone have replaced their large, poorly adapted predecessors, nuclear power's Goliath-like architecture is destined to lose out to "small-is-better" fuel cells, microturbines and scaled-to-need renewable energy systems. Since the technology has never solved the problem of socially and ecologically acceptable disposal of its (highly toxic) waste, surely Korean society can welcome a strategy that foregoes the catastrophic risks unavoidably created by nuclear power.

What might be gained from the pursuit of a *JISEEF I* path? Public health would improve. The nation's very special ecological endowment would be preserved and a greater diversity of life could be supported on the peninsula. Requiring less energy to make goods and services, Korea's economy would be better able to compete in the global marketplace. A *JISEEF I* energy system would be subject to community oversight and governance, moving decision making out of the recesses of the expertocracy that presently determines the sector's planning, and into the daylight of individual and community choice. And, considering the recent warming of relations between North and South, what more effective way for the people of the peninsula to cooperate than in a technologically and ecologically forward-looking development strategy? Rather than building obsolescence into both countries' futures, *JISEEF*

*I* would reduce energy investment demand by cutting energy waste and, thereby, freeing up preciously needed capital for long-delayed social improvements across the peninsula.

**Conclusion**

In sum, in addition to its environmental drawbacks, the current energy regime is nearing technological and economic obsolescence. The era of large power plants, high-voltage transmission systems, massive oil cracking and refining complexes, and huge coal mining and transport operations will come to an end soon. Today we compute with PCs rather than mainframes and communicate with cell phones via satellites rather than clunky rotary phones wired to antique switching systems (Figure 8). The "small is better" revolution that transformed computation and communication has a bead on our energy infrastructure.

In a decade, the old platform of big, centralized and risky technologies will be replaced with a new one built on microturbines, high-efficiency end-use equipment, fuel cells and scaled-to-need renewable energy systems. Alongside these technology changes, there are potent forces of the so-called "new economy" of information and services that will command investment interest while the industrial economy rusts. The new economic drivers will change the way we think about energy – and much else in the global economy.

We will have the opportunity in the new century to replace the technologies and economies of scale that dominated the industrial era – and concentrated the bulk of productive capacity in the hands of a few nations and corporations – with those of diversity and participation. The possibility exists of combining "small is better," "open access" internet technology with the power of ideas to construct a dramatically different future in which economic and technological decentralization, environmental conservation, and social equity are rewarded rather than their current antitheses.

Of course, if we allow the old energy order to arrest its decline by providing its stakeholders with even higher subsidies to create the false impression that "cheap energy" is once more available, we may delay this opportunity. It will be up to each society not to let this happen.

Taiwan's stake in a forward-looking energy and environmental strategy is clear. It has the choice of the Binnan heavy industrial complex and its threats to the endangered black-faced spoonbill bird population, or a sustainable development strategy that rewards Chiku's residents for their century-long maintenance of the special habitat needed by this majestic bird. And it has the choice of subsidizing continued construction of two nuclear power plants at Kungliao and falling behind in the competition for the new green economy and sustainable cities. Or Taiwan can choose to lead in the 21st century, by building a sustainable and peaceful energy infrastructure which elicits its citizens' praise, rather than their protests. Inescapably, the decisions made on these matters will dramatically affect Taiwan's domestic and international future.

**Table 1**

## Characteristics of Greenhouse Gases Affected by Human Activities

| | $CO_2$ | $CH_4$ | $N_2O$ | CFC-11 | HCFC-22 | $CF_4$ |
|---|---|---|---|---|---|---|
| Pre-industrial Concentration | ~280 ppmv | ~700 ppbv | ~275 ppbv | zero | zero | zero |
| Concentration in 1994 | 358 ppmv | 1720 ppbv | 312 ppbv | 268 pptv | 110 pptv | 72 pptv |
| Rate of Concentration Change* | 1.5 ppmv/yr 0.4 %/yr | 10 ppbv/yr 0.6 %/yr | 0.8 ppbv/yr 0.25 %/yr | 0 pptv/yr 0 %/yr | 5 pptv/yr 5 %/yr | 1.2 pptv/yr 2 %/yr |
| Atmospheric lifetime (years) | 50 - 200 | 12 | 120 | 50 | 12 | 50,000 |

* The growth rates of $CO_2$, $CH_4$, and $N_2O$ are averaged over the decad beginning in 1984; halocarbon growth rates are based on recent years.
Source:Intergovernmental Panel on Climate Change.

**Table 2**

**Potential Impacts of Climate Change on Small Islands**

- Inundation of deltas, estuaries and coastal wetlands
- Destruction of benthic systems, especially sea grass beds
- Loss of productivity of coastal ecosystems
- Flooding in coastal plains
- Increased coastal erosion
- Increased saline intrusion leading to aquifer contamination
- Displacement of traditional fishing sites
- Coral reef deterioration due to thermal stress and SLR
- Damage to coastal infrastructure
- Increased vulnerability of human settlements
- Loss of agricultural land
- Damage to industrial infrastructure

**Table 3**

# $CO_2$ Reduction Scenarios for Japan

| Scenarios to Address Climate Change | Projected $CO_2$ Change (over 1990 Levels) 2005 | 2010 |
|---|---|---|
| BAU Case | +19% | +25% |
| Technology Only Scenario | -2% | -9% |
| Technology & Industrial Restructuring | -12% | -21% |

Source: CASA Climate Change Strategy Team Report . Osaka, Japan. (October, 1997)

**Table 4**
**Summary of Primary Energy Savings and $CO_2$ Emission Reductions in 2020 for the JISEEF I Scenario by End Use Sector**

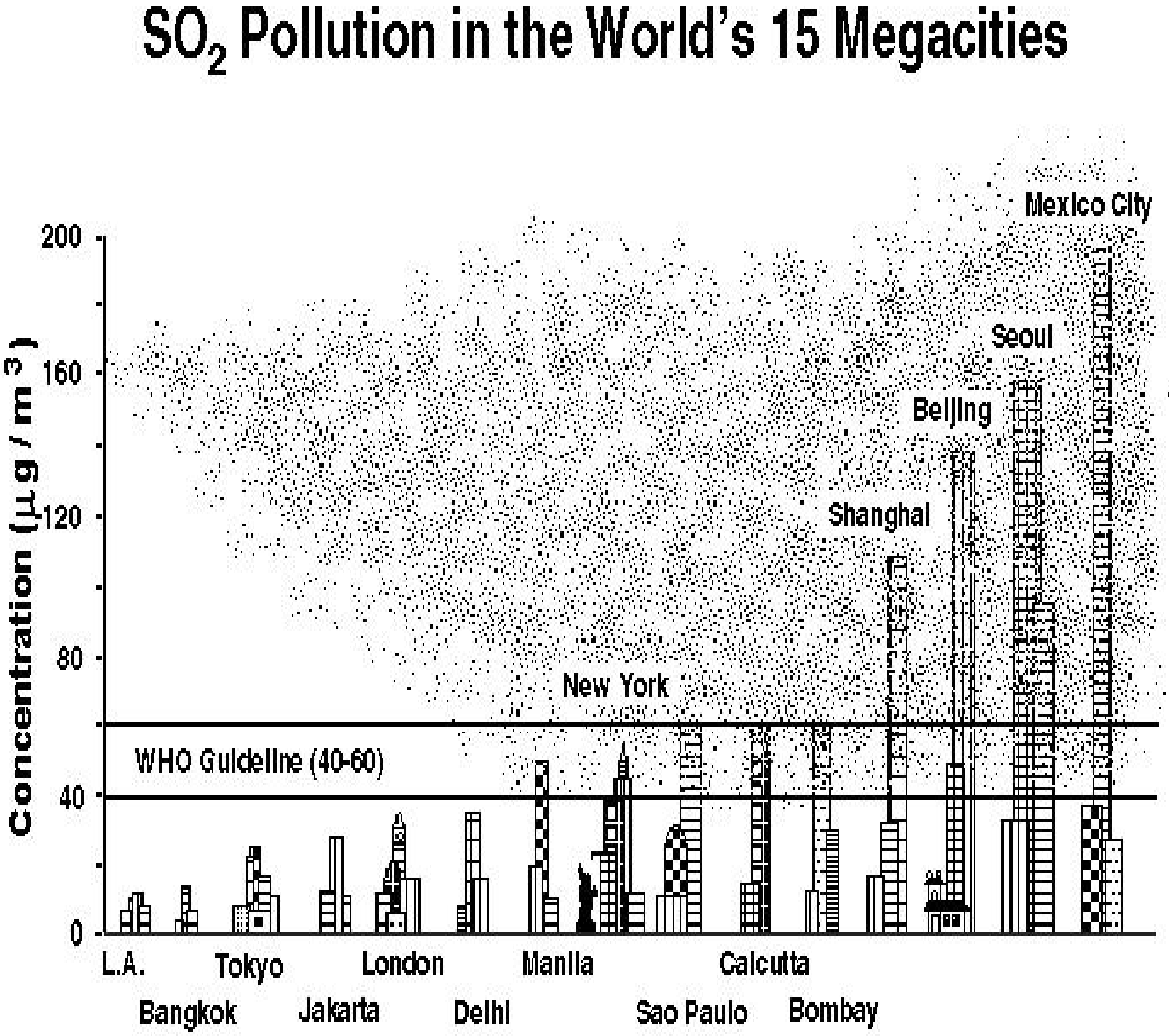
(Unit: MTOE, MTC)

| Sector | Full Implementation (100%) | Major Policy Commitment (65%) |
|---|---|---|
| **Industrial** | | |
| · Energy | 35.6 | 23.1 |
| · $CO_2$ | 20.1 | 13.1 |
| **Transportation** | | |
| · Energy | 16.8 | 10.9 |
| · $CO_2$ | 13.5 | 8.8 |
| **Residential** | | |
| · Energy | 17.0 | 12.9 |
| · $CO_2$ | 10.8 | 7.2 |
| **Commercial** | | |
| · Energy | 17.0 | 11.1 |
| · $CO_2$ | 8.3 | 5.4 |
| **TOTAL SAVINGS** | | |
| · Energy | 86.4 (28.2% $\downarrow$) | 58.0 (18.9% $\downarrow$) |
| · $CO_2$ | 52.7 (28.1% $\downarrow$) | 34.5 (18.4% $\downarrow$) |
| **MTOE in 2000: BAU** | **180.8** | **180.8** |
| **MTOE in 2020: BAU** | **306.3** | **306.3** |
| **$CO_2$ Emissions in 2000: BAU[1]** | **116.9** | **116.9** |
| **$CO_2$ Emissions in 2020: BAU** | **187.4** | **187.4** |
| **Energy Reduction with Nuclear Moratorium** | **32.8** | **21.4** |
| **$CO_2$ Reduction with Nuclear Moratorium** | **52.7** | **31.9[2]** |
| **$CO_2$ Emissions in 2020 for JISEEF Scenario I** | **134.7** | **152.9** |
| **Additional $CO_2$ Reduction Needed to Meet a Year 2000 Emissions Cap** | **17.8** | **36.0** |

Note: [1] The Business-as-Usual (BAU) forecast is provided in MOCIE/KEEI's *the Second-Year Study of Planning National Actions for the United Nations Framework Convention on Climate Change* (December 1998) and also provided in tabular forms by KEEI in May 1999.
[2] This figure is adjusted for increased emissions from LNG plants running at a higher capacity factor (34.5 MTC - 2.6 MTC).

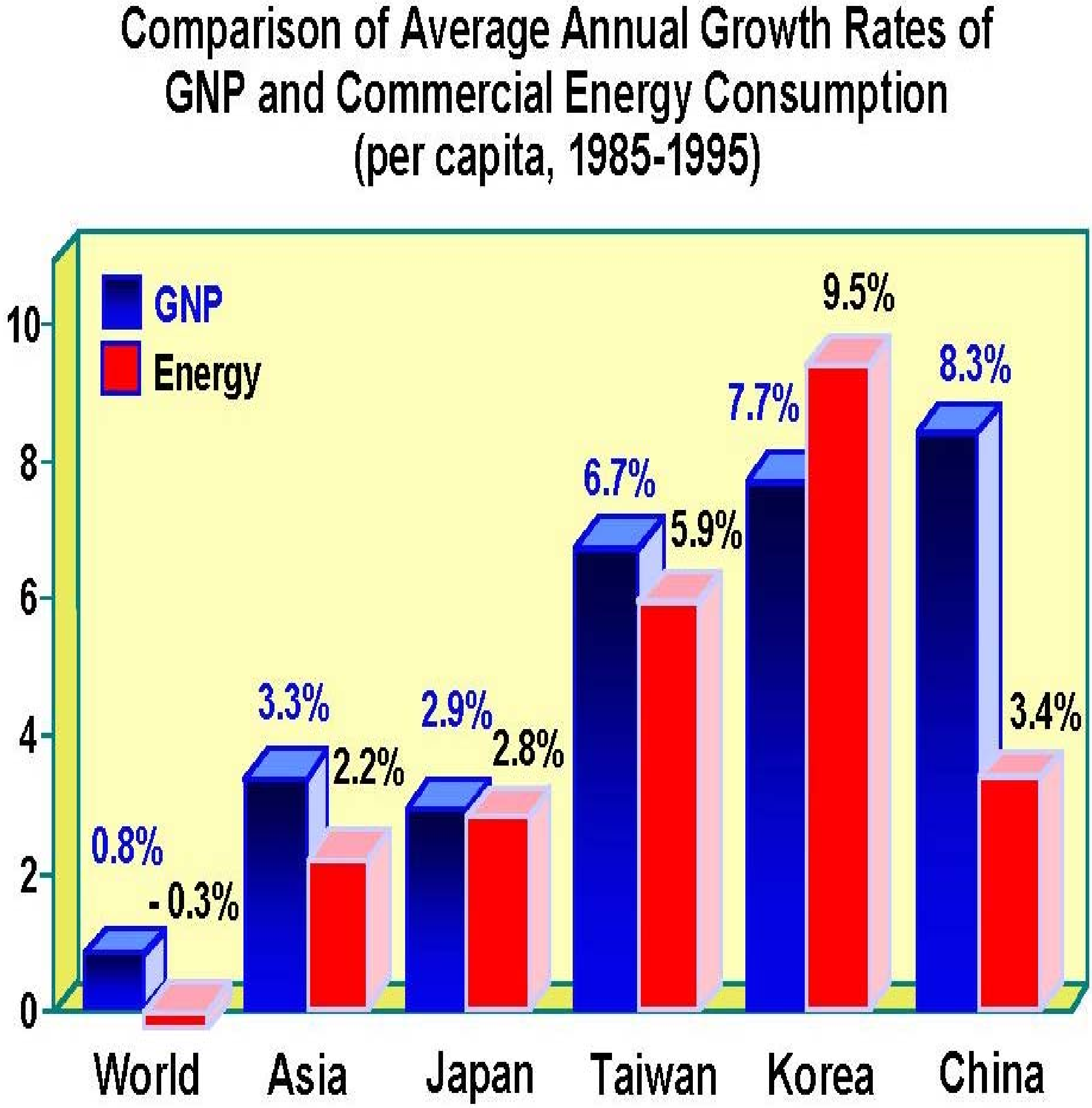
Source: *Toward a Sustainable Energy and Environmental Strategy for South Korea: Volume 1*. 2000. Prepared by the Joint Institute for Sustainable Energy and Environmental Futures (JISEEF), an international research consortium partially supported by the W. Alton Jones Foundation. For further information, please contact John Byrne, Director, Center of Energy and Environmental Policy, University of Delaware.

**Figure 1**



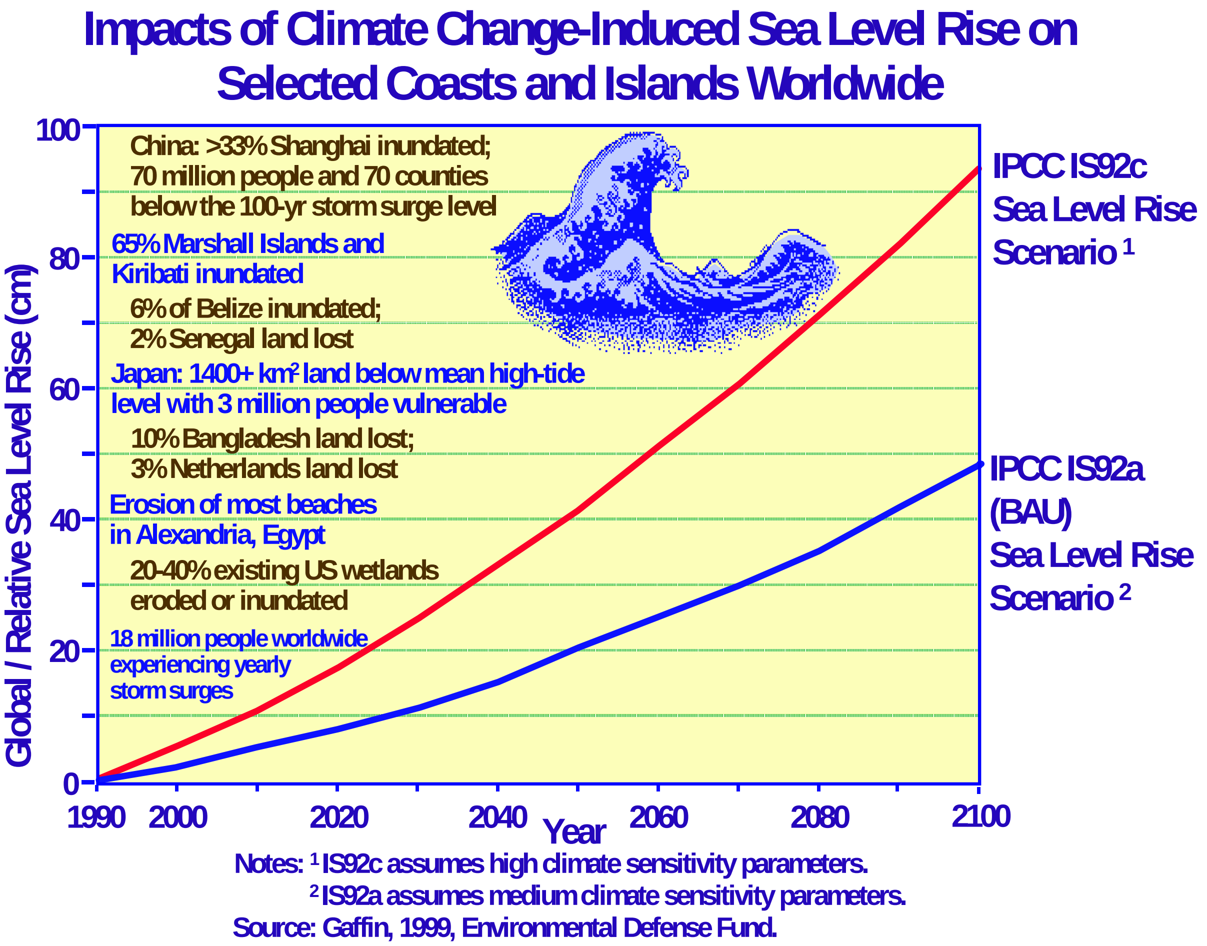

Source: WHO and UNDP. 1992. *Urban Air Pollution in Megacities of the World.* Cambridge, MA: Blackwell Reference (Published on behalf of World Health Organization and United Nations Environment Programme).

**Figure 2**



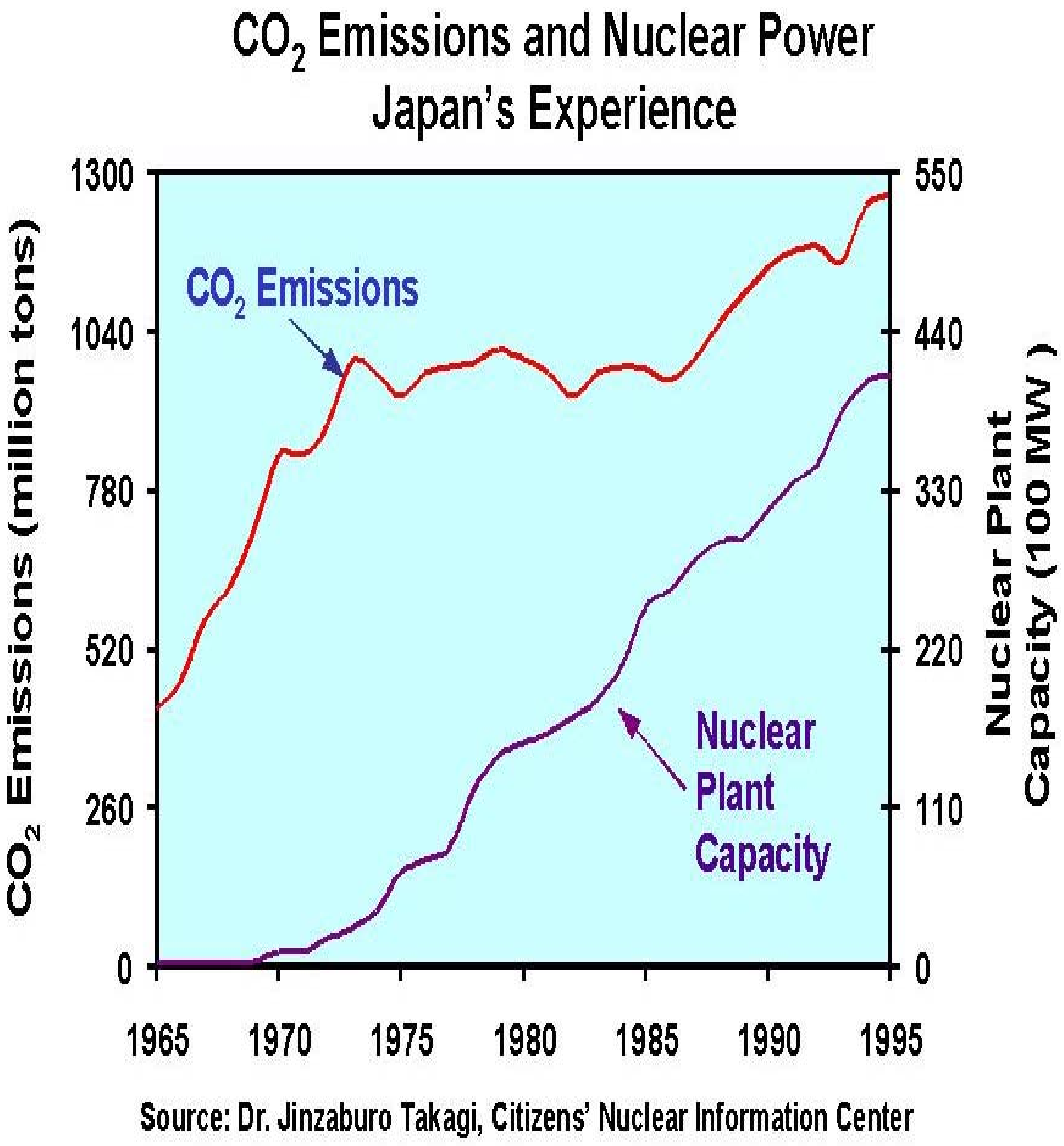

Source: Center for Energy and Environmental Policy, University of Delaware.

**Figure 3**



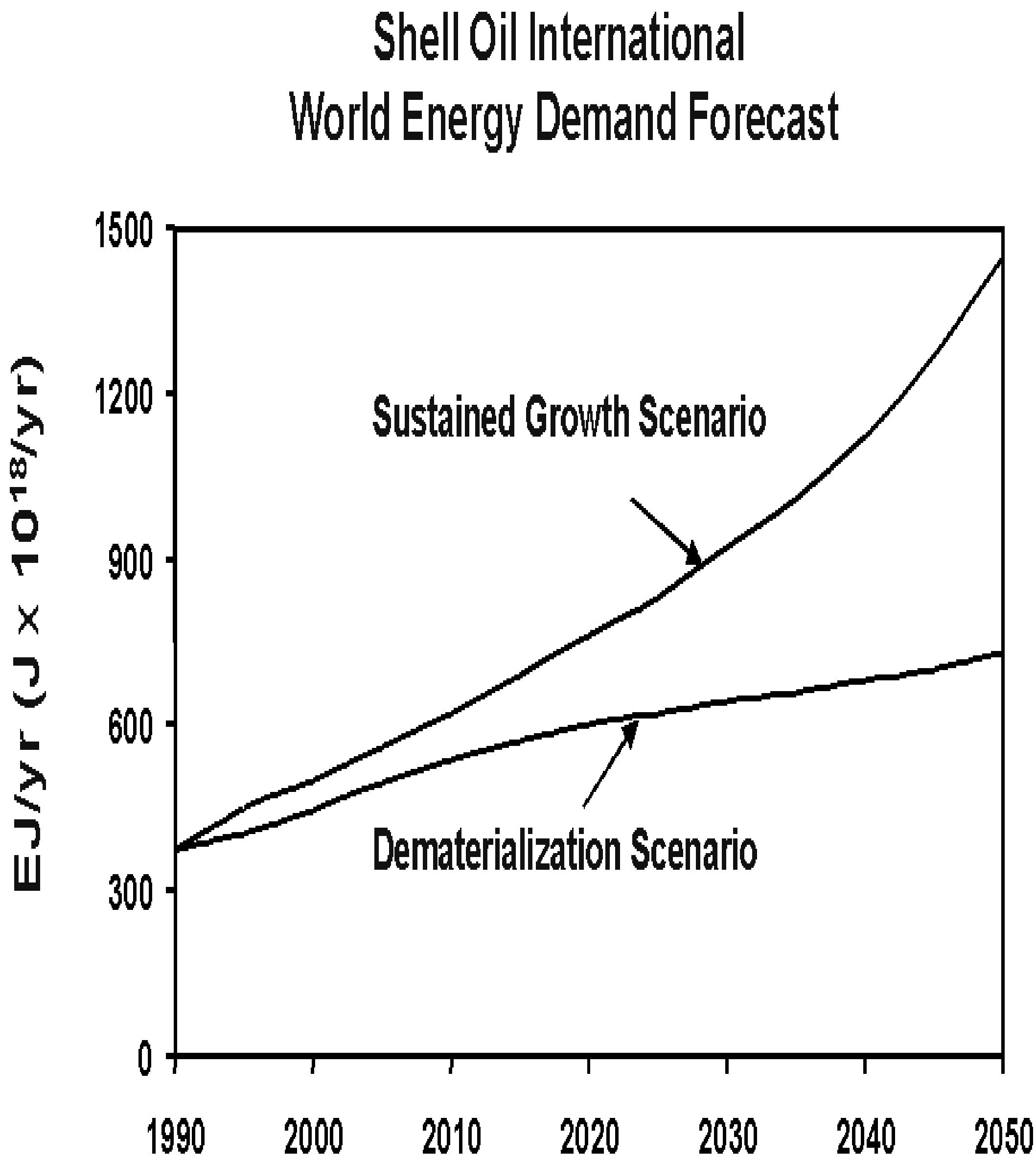
Impacts of Climate Change-Induced Sea Level Rise on Selected Coasts and Islands Worldwide
China: >33% Shanghai inundated; 70 million people and 70 counties below the 100-yr storm surge level
65% Marshall Islands and Kiribati inundated
6% of Belize inundated; 2% Senegal land lost
Japan: 1400+ km² land below mean high-tide level with 3 million people vulnerable
10% Bangladesh land lost; 3% Netherlands land lost
Erosion of most beaches in Alexandria, Egypt
20-40% existing US wetlands eroded or inundated
18 million people worldwide experiencing yearly storm surges
IPCC IS92c Sea Level Rise Scenario 1
IPCC IS92a (BAU) Sea Level Rise Scenario 2
Global / Relative Sea Level Rise (cm)
0
20
40
60
80
100
Year
1990
2000
2020
2040
2060
2080
2100
Notes: 1 IS92c assumes high climate sensitivity parameters.
2 IS92a assumes medium climate sensitivity parameters.
Source: Gaffin, 1999, Environmental Defense Fund.

**Figure 4**



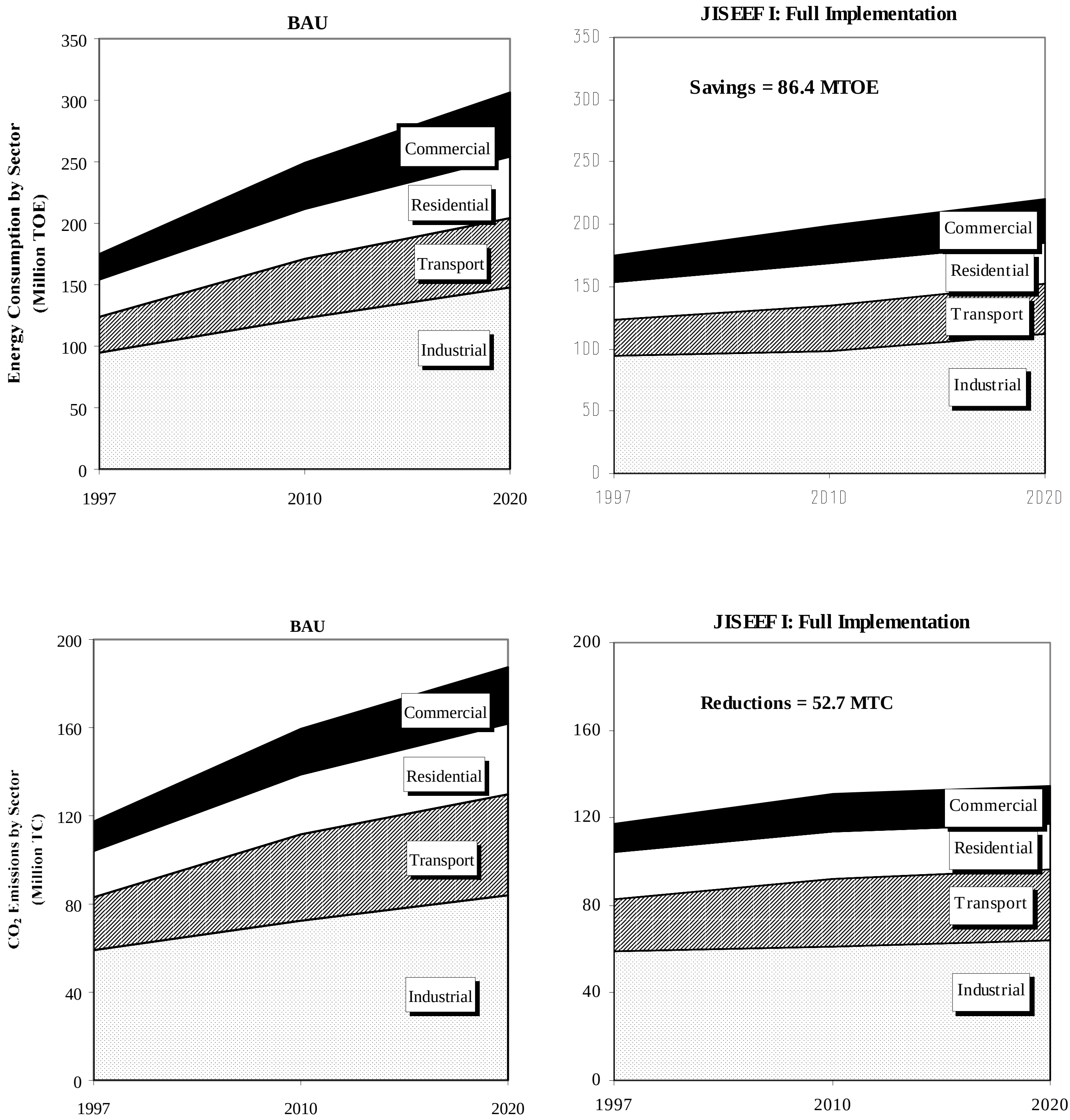
CO2 Emissions and Nuclear Power
Japan's Experience
CO2 Emissions (million tons)
Nuclear Plant Capacity (100 MW )
1300
1040
780
520
260
0
550
440
330
220
110
0
CO2 Emissions
Nuclear Plant Capacity
1965
1970
1975
1980
1985
1990
1995
Source: Dr. Jinzaburo Takagi, Citizens' Nuclear Information Center

**Figure 5**



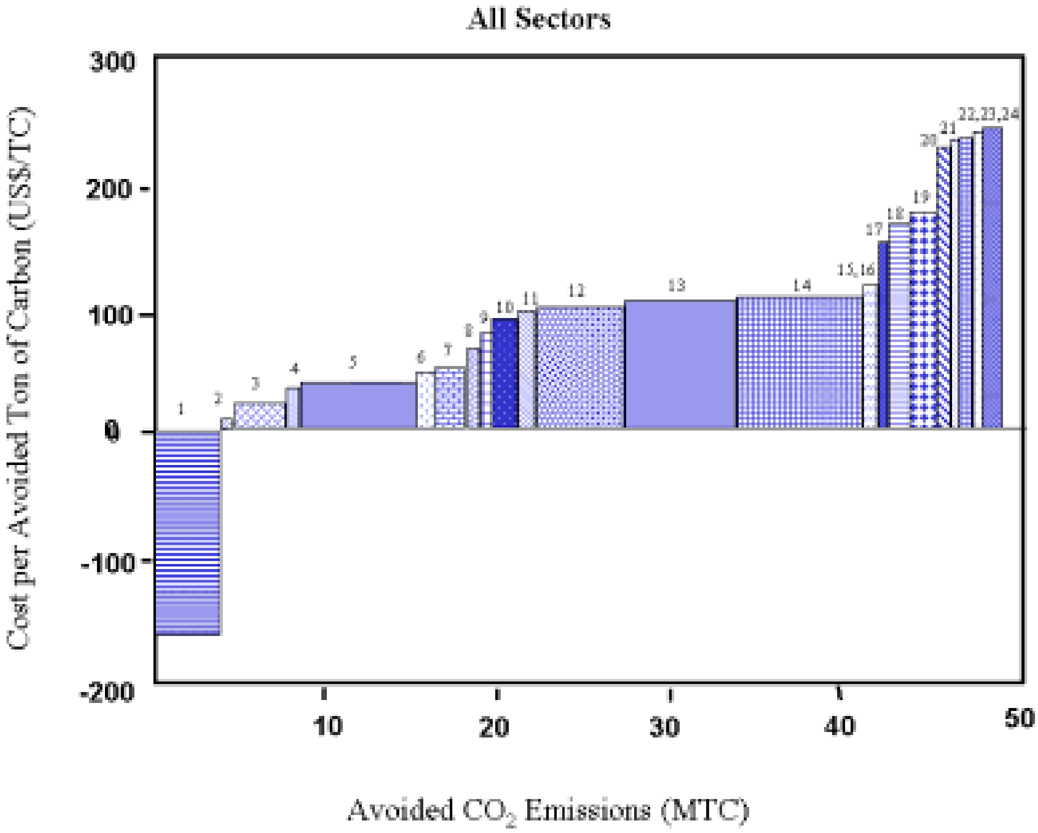

Source: Shell Oil, *The Evolution of the World's Energy Systems*

**Figure 6**
**South Korea's Energy Consumption and $CO_2$ Emissions in 2020:**
**BAU and the JISEEF I Full Implementation Scenario**




Source: see Table 3.

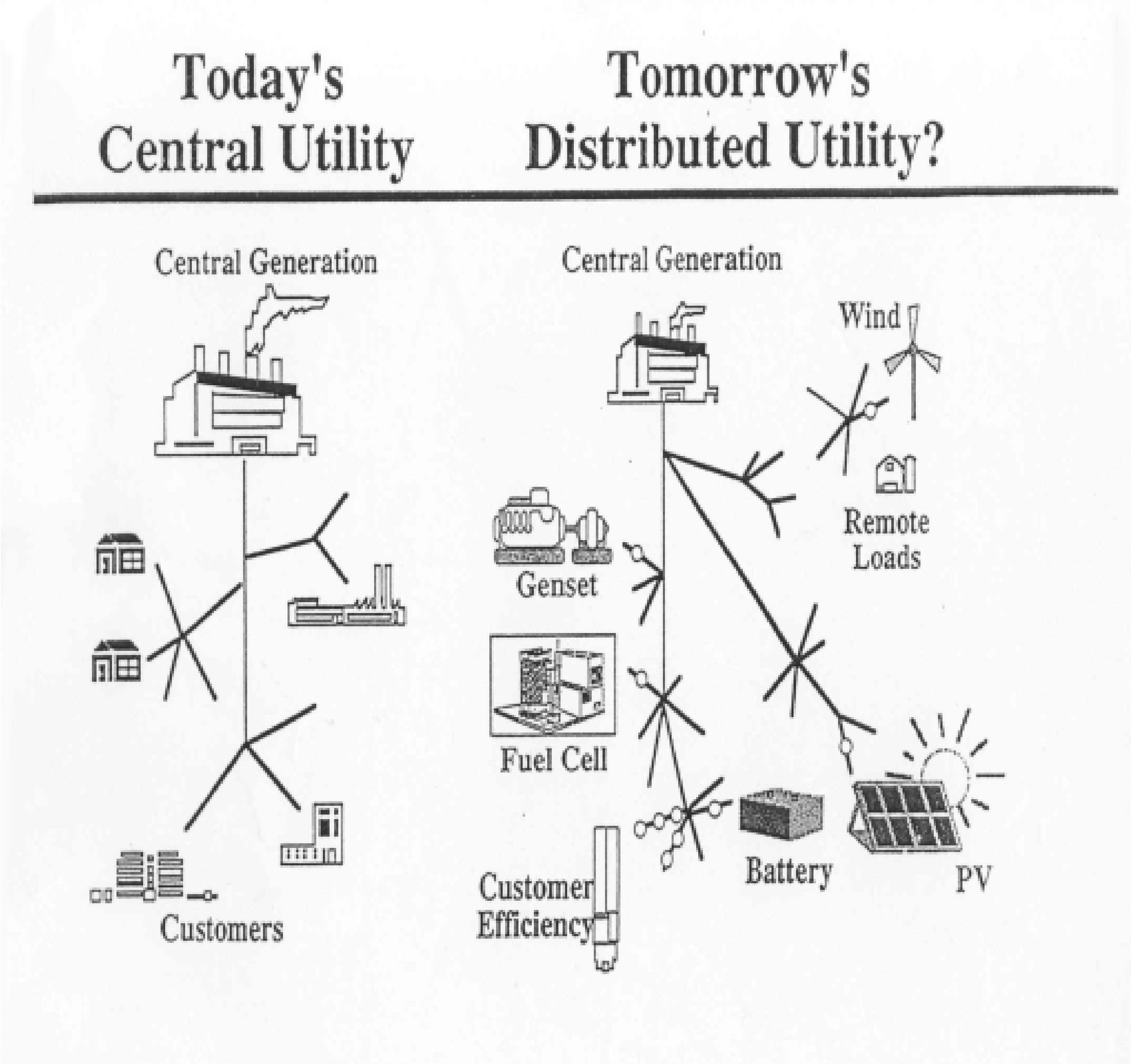
**Figure 7**
**An Illustrative Supply Curve of Avoided $CO_2$ Emissions in South Korea**




Note:
1. Commercial Lighting Upgrades
2. Improved Industrial O&M
3. Improved Industrial Combustion Systems
4. Improved Industrial Building & Grounds
5. Improved Industrial Thermal Systems
6. Commercial Cooling Upgrades
7. Improved Industrial Motor Drives
8. Higher-Efficiency Heavy-Duty Trucks
9. Higher-Efficiency Light-Duty Trucks
10. Commercial Heating Upgrades
11. Higher-Efficiency Buses
12. Residential Heating Upgrades
13. Higher-Efficiency Passenger Cars
14. Cogeneration
15. CNG Buses
16. Residential Air Conditioning Upgrades
17. CNG Passenger Cars
18. Residential Lighting Upgrades
19. Commercial Motor Upgrades
20. EV Passenger Cars
21. Residential Refrigeration Upgrades
22. Commercial Shell Technology Upgrades
23. Residential Shell Technology Upgrades
24. EV Buses

Source: see Table 3.

**Figure 8**
**Centralized versus Distributed Utility Architectures**



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