PART II: ENERGY, THE COMMON DENOMINATOR

3. Energy and Development

Driver for Economic and Human Growth

43. All life on Earth is sustained by energy, whether taken directly from the sun or indirectly by consuming other organisms that do. Human civilization, in particular, has flourished by using far greater amounts of energy extrasomatically (i.e., outside the body) than required for basic survival, harnessing it for improving living conditions, agricultural productivity, industrial advancement, and health, cultural, and scientific betterment. This has, in turn, had an enormous effect on human society, individual and communal behavior, and social evolution, with the emergence of unprecedented affluence and large-scale urbanization and industrialization—resulting in seemingly insatiable consumption requirements. Such demand dictates commensurate increases in the provision of food supplies, consumer and durable goods, communication and transportation networks, social services, cultural and recreational facilities, and provision for other personal and collective needs, on the one hand, and correspondingly vast and sophisticated support mechanisms in the form of large-scale manufacturing and technological capabilities, complex supply chains, and the necessary commercial, political, and security underpinnings, to name a few, on the other. In recent decades these trends have accelerated worldwide, fuelled by a rapidly growing world population and fed by increasingly efficient industry and agriculture, the globalization of marketing-driven consumption patterns, and shortening cycles of technological obsolescence. Levels of human prosperity, although still marked by stark inequalities between countries and social groups, have been on the rise, and the pockets and ranks of the relatively well-off have been expanding steadily, although tempered by higher population growth rates among the poorest.

44. All such progress depends vitally on modern energy supplies and transformation systems—primarily processed liquid and gaseous fuels and electricity—without which it would not have been possible to move beyond fulfilling very basic human subsistence needs. That many parts of the world still lack access to such forms of energy, in whole or in part (as described in **Part I**), explains the invariably poor condition of human existence and the persistence of debilitating poverty there. Modern forms of energy are necessary for increasing the productivity of labor and agriculture; improving health, education, and social welfare; lowering transportation and transaction costs; providing greater opportunities for employment and income-generation; and connecting communities to economic, trade, and information networks and resources that can lead to self-sustaining growth and, inevitably, the only means of escaping the “poverty trap”. On the other side of the coin, citizens of technologically advanced nations, with their per capita energy consumption a hundred times greater than that required for rudimentary existence, enjoy the highest levels of income, living standards, health care and life expectancy, and a wide array of available economic, intellectual, and cultural pursuits.

Powering Development

45. The link between access and use of modern energy services[7] and human development is obvious and very strong, and the empirical evidence supporting which has been extensively documented and merits discussion here. In particular, the relationship between electricity consumption per capita and the human development index (HDI)[8] has been found to be better defined than that between the latter and primary energy use.[9] The HDI, compiled and published annually by the United Nations for its member countries, is a useful standardized measure of "human development" for comparative purposes that takes into account life expectancy, education, and standard of living (through per capita income) that is not derived primarily from economic or energy use statistics. This is important, as human development is about much more than the simple acquisition of financial assets: it is the ability to pursue individual choices—resulting in productive, creative lives—through increased longevity and health, enriched by knowledge and higher standards of living, and the freedom to participate in communities' and nations' affairs.[10]

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[7] "**Energy services** are the benefits that energy carriers produce for human well being. Examples of energy services include heat for cooking, illumination for home or business use, mechanical power for pumping or grinding, communication, and cooling for refrigeration. Energy services can be derived from a variety of energy carriers. For instance, illumination can be produced by fuels or by electricity. Mechanical power can be produced from kinetic or potential energy of water, from kinetic energy of wind, from a liquid fuel, or from electricity. Energy carriers, in turn, can be derived from a variety of primary energy sources; electricity for example can be generated from hydropower, petroleum, solar, or wind energy. From the point of view of the user, what matters is the energy service not the source. Whether in business, home, or community life, what matters are the reliability, affordability, and accessibility of the energy service." (Modi, V., S. McDade, D. Lallement, and J. Saghir. 2006 *Energy Services for the Millennium Development Goals*, p. 9).

[8] "The Human Development Index (HDI) is a composite index that measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, as measured by life expectancy at birth; knowledge, as measured by the adult literacy rate and the combined gross enrolment ratio for primary, secondary and tertiary schools; and a decent standard of living, as measured by GDP per capita in purchasing power parity (PPP) US dollars." (United Nations Development Programme [UNDP]. 2006. *Human Development Report 2005*, p. 214).

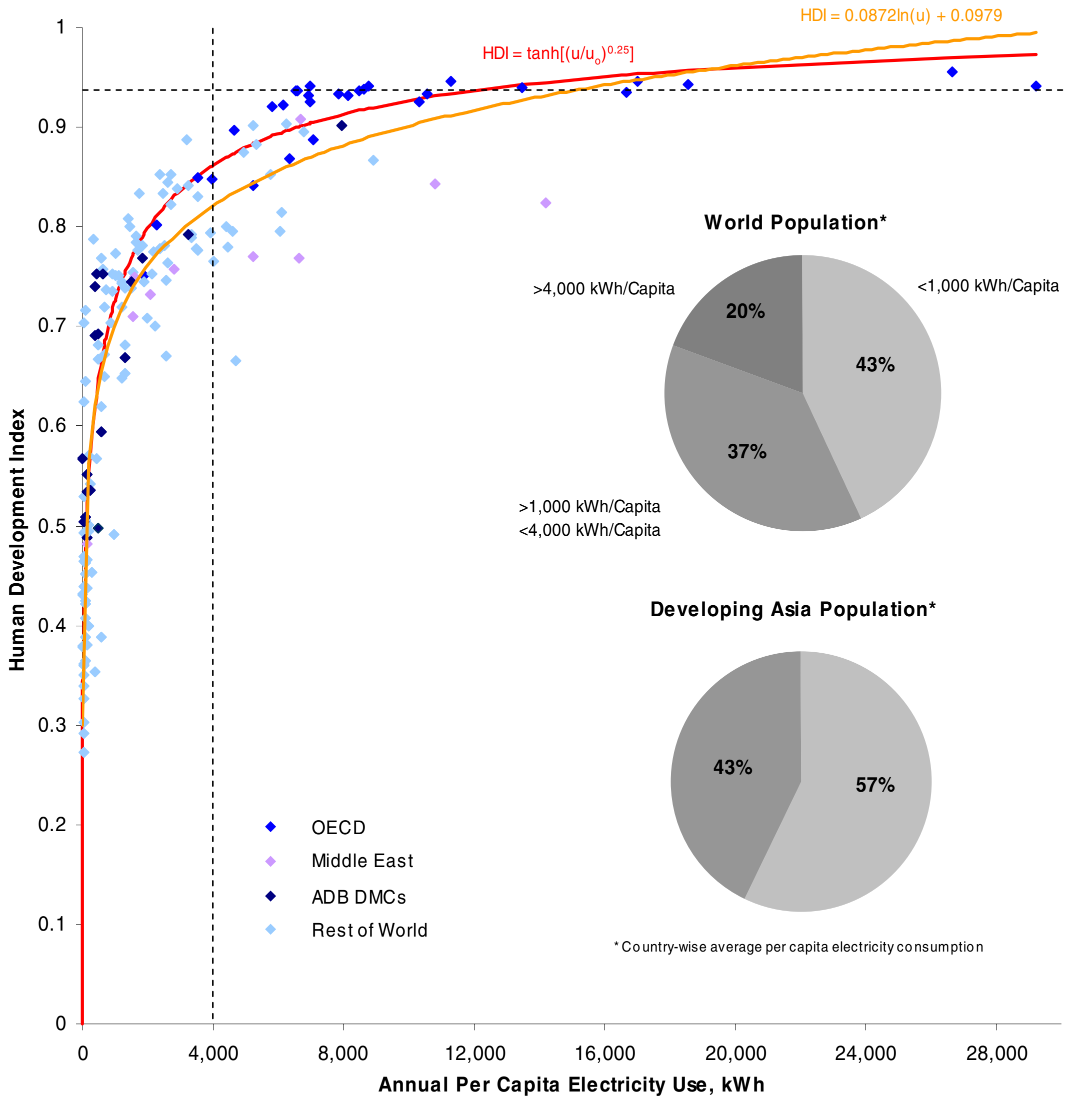
[9] For instance, see Garcia, M. 2006. An Introduction Linking Energy Use and Human Development. *Energy for Human Development, Report 1*; and Pasternak, A.D. 2000. Global Energy Futures and Human Development: A Framework for Analysis.

[10] "The basic purpose of development is to enlarge people's choices. In principle, these choices can be infinite and can change over time. People often value achievements that do not show up at all, or not immediately, in income or growth figures: greater access to knowledge, better nutrition and health services, more secure livelihoods, security against crime and physical violence, satisfying leisure hours, political and cultural freedoms and sense of participation in community activities. The objective of development is to create an enabling environment for people to enjoy long, healthy and creative lives." Dr. Mahbub ul Haq, creator of the HDI.

46. **Figure 32** shows HDI values for 171 countries plotted against their respective annual per capita electricity consumption in 2002. As is evident from the diagram and from detailed investigation of the relationship between the two factors, it appears that there is an approximate 4,000 kilowatt-hour (kWh)/capita threshold, corresponding to an HDI value of about 0.9, beyond which the plotted trend plateaus.[11] It is apparent from the figure that the higher per capita consumption levels (>7,000 kWh/capita) are populated exclusively by developed or affluent oil-producing Middle and Far East countries, although the latter fall consistently below the 0.9 HDI threshold. With only a couple of exceptions (Mexico and Poland), virtually all Organisation for Economic Co-operation and Development (OECD) economies consumed more than 4,000 kWh/capita of electricity, while all of developing Asia (except Singapore) fell below this threshold in 2002. On a global scale, only 20% of the world's population used 4,000 kilowatt-hours (kWh) or more of electricity per person in 2002 (based on country-wise aggregation), up slightly from 18.4% in 1997, while 43% used less than 1,000 kWh/capita, down from 66.2% in 1997. Thus, while many developing countries have progressed in moving up the steep end of the curve, very few have managed to cross the 4,000 kWh/capita threshold during this period. Compared with this benchmark, some 80% of the world's population and almost 100% of developing Asia's continued to live with relatively little electricity consumption, and exhibited commensurate low levels of human development indices for their inhabitants.

[11] Pasternak [Pasternak, A.D. 2000. Global Energy Futures and Human Development: A Framework for Analysis] derived this significant inflexion point based on 1997 data for 60 countries, and found a best-fit curve of $HDI = 0.091\ln(u) + 0.0724$, where u is the per capita electricity consumption in kWh, with an 84% correlation factor (to 28,000 kWh/capita). He also found the 4,000 kWh/capita threshold for 1980 data for 73 countries, although the HDI plateau in this case was slightly lower at 0.875. Garcia [Garcia, M. 2006. An Introduction Linking Energy Use and Human Development. *Energy for Human Development, Report 1*] found a better derivation of the relationship in the form $HDI = \tanh[(u/u_o)^{0.25}]$, where u_o = 1,400 kWh/capita is a normalization factor, that—unlike the logarithmic function—also conforms to the assumed asymptotic limits of $u \rightarrow 0$, $HDI \rightarrow 0$ and $u \rightarrow \infty$, $HDI \rightarrow 1$, and found that a consumption of 4,000 kWh/capita corresponded to an HDI of 0.862, based on 2005 data for 177 countries. In **Figure 32**, both correlation curves are shown for comparison of 2002 data for 171 countries, with the logarithmic fit $HDI = 0.0872\ln(u) + 0.0979$ having an 80% correlation factor (to 30,000 kWh/capita). The knee at u = 4,000 kWh/capita (vertical dashed line) and fit for high-u data are clearly more pronounced for the hyperbolic tangent curve, but it can be seen that the former still corresponds to u = 4,000 kWh/capita and a corresponding HDI of 0.862, beyond which the actual data points tend to flatten out at an HDI of 0.935 (horizontal dashed line). **Figure 33** demonstrates that the correlation for cross-sectional country data shown in **Figure 32** is also valid for time series data, i.e., countries tend to move along the curve.

Figure 32: Human Development Index and Electricity Use by Country, 2002



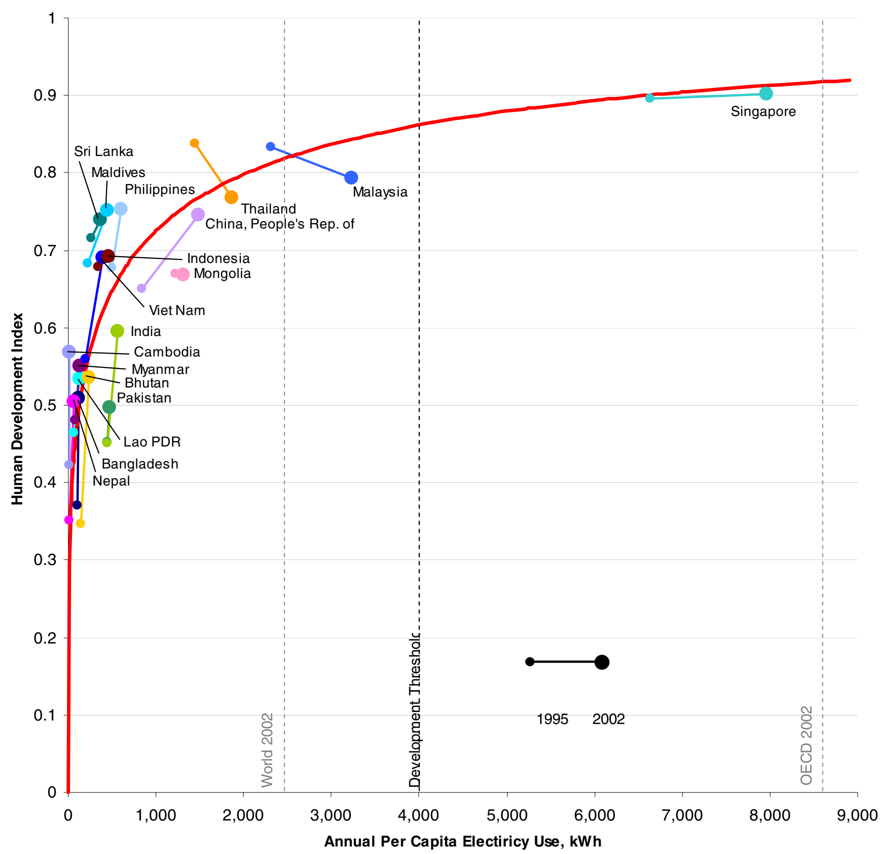
ADB = Asian Development Bank; DMC = developing member country; HDI = human development index; kWh = kilowatt-hour; OECD = Organisation for Economic Co-operation and Development.

Note: Refer to footnote 11 for correlation curves.

Source: United Nations Development Programme (UNDP). 2006. *Human Development Reports.* New York: UNDP. Available: http://hdr.undp.org/statistics/data.

47. The movement of developing Asian countries up the steep end of the HDI-u curve over the period 1995 to 2002 (the earliest and latest years, respectively, for which such data has been published by the United Nations Development Programme [UNDP]) is shown in **Figure 33**. As expected, the sample has largely tracked the asymptotic curve, with countries at the bottom of the scale (Bangladesh, Bhutan, Cambodia, India, the Lao People's Democratic Republic [Lao PDR], Mongolia, Myanmar, Nepal, Pakistan, and Viet Nam) making discernable improvements in their HDI values with only marginal increases in per capita energy consumption, while those at the higher end (especially Malaysia, Singapore, and Thailand) increased their per capita energy consumption significantly with little or no improvement in their already high HDI standings. The People's Republic of China (PRC), at the transitional cusp in the curve, marked significant increases in both per capita electricity consumption and HDI during this period. On the flip side, this also points out the difficulty for the aforementioned 10 poorer Asian nations—where investments are most needed to achieve acceptable levels of human development—to rapidly expand their energy supplies and infrastructure, particularly given the pressures of a growing population base. Thus, virtually all of these countries have been able to move vertically up the curve toward relatively better HDI scores, but have hardly exhibited any horizontal movement across to higher levels of per capita electricity. As a result, in absolute terms, their human development indices remain unacceptably low at less than 0.6, well below the 0.9 transitional mark.

Figure 33: Developing Asia's Human Development Index and Electricity Use, 1995 and 2002



kWh = kilowatt-hour; Lao PDR = Lao People's Democratic Republic; OECD = Organisation for Economic Co-operation and Development.

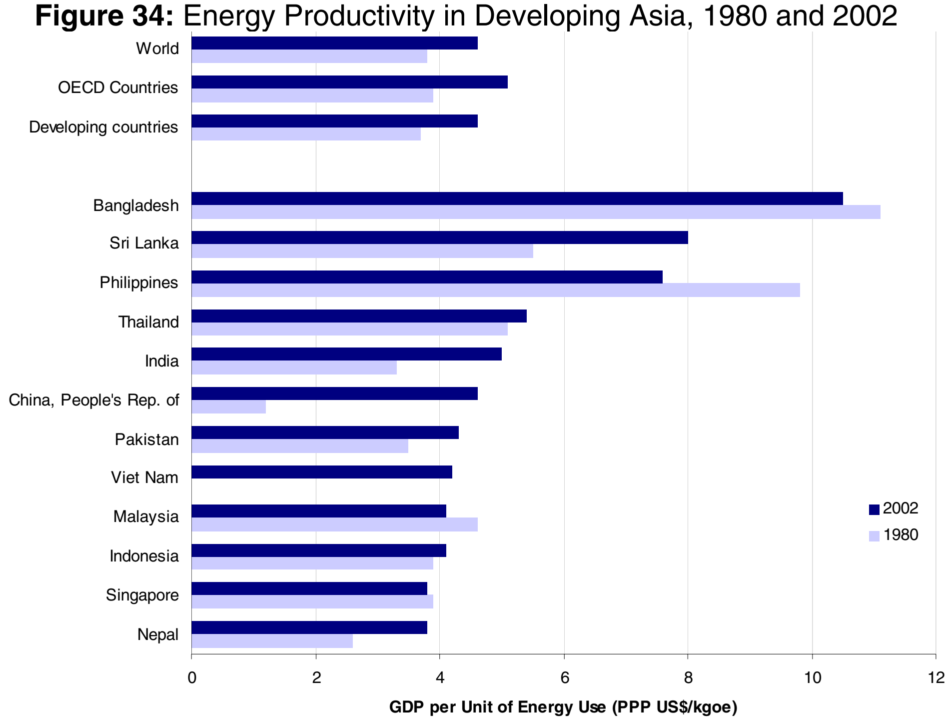
Source: UNDP. 2006. *Human Development Reports.* New York: UNDP. Available: http://hdr.undp.org/statistics/data.

48. **Figure 28** shows the change in per capita electricity consumption for Asian countries between 1980 and 2002 and comparative worldwide averages, which illustrates regional disparities and the slow pace of progress toward the important benchmark of 4,000 kWh/capita by developing Asia (with the exception of the fast-growth economies of the PRC, Malaysia, and Thailand).

Intensity of Use

49. In addition to reasonably high levels of per capita electricity consumption, lower energy intensity (i.e., energy required to produce a unit of gross domestic product [GDP]) is also desirable, as it represents greater efficiency in converting energy to income. Countries with an HDI of 0.9 or higher typically represent low energy and electricity intensities in their economies, and vice versa.[12] **Figure 34** shows the energy productivity, or the inverse of energy intensity (in terms of GDP at Purchasing Power Parity US$ per kilogram of oil equivalent used), for several developing Asian countries for which such data are available, compared with world, OECD and overall developing country averages, for the years 1980 and 2002. As can be seen, the higher growth-low HDI economies of the PRC and South Asia (with the exception of Bangladesh) have exhibited a decreasing intensity trend over this 22-year period, but remain above world and OECD levels (i.e., lower in terms of energy productivity). Bangladesh, Sri Lanka, and the Philippines, however, demonstrate much lower energy intensities; in the case of Bangladesh, however, this is also accompanied by relatively low HDI values. Energy intensity in even the more developed economies of Malaysia, Singapore, and Indonesia has stagnated above the OECD average over this period.

Figure 34: Energy Productivity in Developing Asia, 1980 and 2002



GDP = gross domestic product; kgoe = kilogram of oil equivalent; OECD = Organisation for Economic Co-operation and Development; PPP = purchasing power parity; US = United States.
Source: UNDP. 2006. *Human Development Reports.* New York: UNDP. Available: http://hdr.undp.org/statistics/data.

[12] Exceptions include countries with relatively lower HDI values as well as energy intensities (such as Saudi Arabia and South Africa), and those with high HDI along with higher energy intensity (such as Canada).

The Asian Deficit

50. Several important conclusions can be drawn from an analysis of plots such as the ones shown in **Figures 32–34** and related data:

1. There exists a strong correlation between per capita energy, specifically electricity, consumption, and levels of human development, with a minimum consumption of 4,000 kWh/capita required in order for a "decent" level of HDI = 0.9 to be attained. This energy consumption threshold (and the corresponding HDI value of 0.86) has remained unchanged in recent decades, even as the HDI plateau for developed nations has gradually risen due to increasing prosperity levels. In fact, 4,000 kWh/capita is at best a conservative benchmark—for comparison, the corresponding average for the G8 countries (excluding the Russian Federation) is over 11,300 kWh/capita, or almost three times higher. In effect, incomes rise with electricity use well beyond the 4,000 kWh/capita threshold, and neither the GDP nor the HDI of developing countries can be expected to increase without a corresponding increase in electricity (and energy) use.
2. In particular, incremental increases in average per capita income can result in dramatic improvements in human development indices for countries that fall below the 4,000 kWh/capita threshold. In other words, there is a very strong "quality of life" payback for even small increases in delivered quantities of modern energy supplies, especially electricity, in most developing countries.
3. Garcia postulates the following broad categorization between per capita electricity consumption and levels of human development: below 1,000 kWh/capita, people subsist in abject poverty, barely able to meet their 8–9 megajoule (MJ)/day survival requirements; 2,000 kWh/capita (close to the world average in 2003 of 2,465 kW/h and an HDI of 0.741) is required to sustain a mix of modern technological components in an otherwise agricultural society; 3,000 kWh/capita results in a high level of socioeconomic development; 4,000 kWh/capita enables the high development plateau of HDI = 0.9 to be reached; modern technological societies without regional disparities or excluded minorities typically require 5,000 kWh/capita on average; and at 6,000 kWh/capita, the highest forms of developed societies can function. Such categorization is at best a rough approximation, with important exceptions in actual country data, but nevertheless provides a practical basis for assessing the energy requirements necessary for human development. Equally important to the average per capita consumption figure is how efficiently energy is distributed and utilized within the country, which ultimately determines its benefits for the population as a whole, and therefore, the overall level of HDI achieved.
4. With the exception of Singapore and Brunei Darussalam, all developing Asian countries had HDI scores of less than 0.8 (and per capita electricity use below 1,300 kWh) in 2002. In particular, the 10 Asian nations at the lower end of the HDI scale (i.e., at or below 0.7)—consisting of Bangladesh, Bhutan, Cambodia, India, the Lao PDR, Mongolia, Myanmar, Nepal, Pakistan, and Viet Nam, and representing almost half of developing Asia's and a quarter of the world's population—stand to benefit the most from increased access to electricity supplies. In terms of population, as much as 57% of the Asian Development Bank (ADB)'s developing member countries' (DMCs) population had a per

capita consumption of less than 1,000 kWh in 2002, compared with a worldwide proportion of 43%. Excluding Sub-Saharan Africa, it is clear that developing Asia represents the least energy-developed region of the world, and with over half of the world's inhabitants, it contains 70% of global population living on less than 1,000 kWh/capita consumption.

5. The challenge of taking the least-developed 10 Asian countries—containing 47% of developing Asia's population—up to the world average HDI of 0.741 would require, among other measures, increasing their per capita electricity consumption to 1,150 kWh, or almost two-and-a-half times their 2002 level of 479 kWh/capita, compared with the 26% increase actually achieved by them on average in the 7 years since 1995. However, in the projections discussed earlier in **Part I**, the major portion of the increase in electricity use will occur in countries that are already above the 4,000 kWh/capita threshold, even though almost half (1,240 gigawatts [GW]) of the worldwide increase (2,640 GW) in installed generation capacity between 2003 and 2030 is expected to take place in developing Asia (**Figure 30)**. This is because the population growth rate in developing Asia more than doubled compared with the OECD countries (0.9% versus 0.4% average annual increase) during the corresponding period.

51. These factors point toward the need for greatly expanding both access to modern forms of energy for the large populations of developing Asian countries as well as, in most cases, doubling or quadrupling per capita energy consumption, particularly electricity use, to be able to achieve decent levels of human development. While the former would call for massive increases in expanding and upgrading the energy infrastructure and distribution networks, the latter would require not only vastly greater energy resources and supplies on a sustainable basis, as described below, but also equally significant gains in the affordability among a rapidly growing population, particularly in the lower income strata, to utilize greater amounts of modern energy services, an aspect explored more fully in **Section 4**.

Sustainability of Energy Use

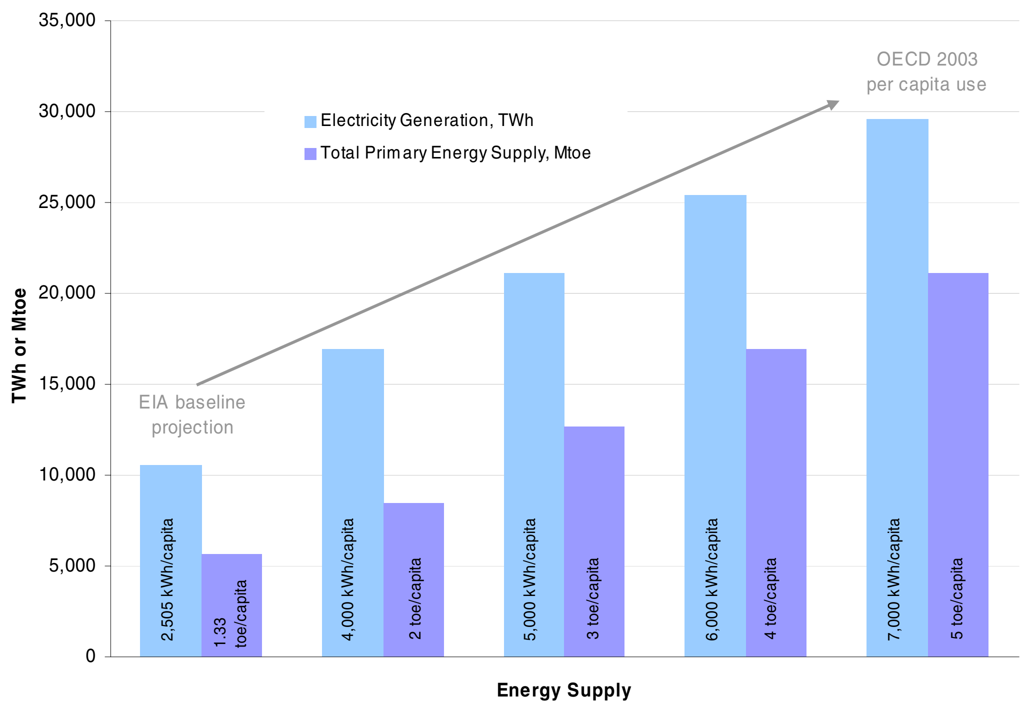
Quantifying Needs

52. The total primary energy and electricity used in the world in 2003 was 10,600 million tons of oil equivalent (Mtoe) and 14,885 terawatt-hours (TWh), respectively, and is expected to increase to as much as 18,185 Mtoe and 31,560 TWh by 2030 at annual growth rates of 2% and 2.8%, respectively, in the Energy Information Administration (EIA) reference scenario. Thus, total energy requirements are expected to increase by almost three quarters over current consumption, while electricity generation will need to more than double over the same period. As noted in **Part I**, this will still leave 1.4 billion people without electricity, only marginally (12.5%) fewer than at present. The impact on per capita use (and hence HDI achievement) is therefore not expected to improve significantly either for large segments of the global and Asian population under current baseline projections.

53. Projected primary energy supply and electricity generation for developing Asia in 2030 under the same scenario is 5,635 Mtoe and 10,600 TWh, which implies a doubling of per capita energy consumption and an almost tripling of per capita electricity use. **Figure 35** shows the total energy supply and electricity generation required for developing Asian countries in 2030 for the attainment of successively higher levels of per capita consumption, up to levels close to those currently enjoyed on average by OECD countries (5.11 toe and 7,683 kWh). Even on a

conservative basis,[13] approximately 50% higher primary energy and electricity supply than forecast under the reference scenario would be required by 2030 for developing Asia to attain the 4,000 kWh per capita threshold corresponding to an HDI of 0.9. In order for these countries to match current per capita consumption levels in the developed world, roughly four times as much primary energy supply and almost three times the power generation projected for 2030 would be needed. This would imply that, to achieve current average OECD per capita consumption levels, developing Asian countries alone would require about the same total energy supply and electricity generation currently projected for the entire world in 2030 (over 1,800 Mtoe and 30,000 TWh, respectively), not counting similarly enhanced requirements if non-Asian developing countries are also to attain the same standards. The requirements would be even greater if higher income countries, rather than the OECD average, are considered for comparison: over 60% more for both total primary energy supply (TPES) and electricity for the least developed Asian countries to match current United States (US) consumption levels, and 100% higher to equal current Canadian use.

Figure 35: Total Energy and Electricity Generation Requirements for Developing Asia at Different Per Capita Use, 2030



EIA = Energy Information Administration; kWh = kilowatt-hour; Mtoe = million tons of oil equivalent; OECD = Organisation for Economic Co-operation and Development; TWh = terawatt –hour.
Note: Based on non-OECD Asia population of 4,231 million in 2030.
Source: US Department of Energy and Energy Information Administration (DOE/EIA). 2006. International Energy Outlook 2006. Report # DOE/EIA-0484 (2006). Washington, DC: EIA, US DOE.

[13] The ratios of primary to electrical energy use were found to be typically less than 10 by Pasternak [Pasternak, A.D. 2000. Global Energy Futures and Human Development: A Framework for Analysis, p. 13] for the 1997 data set, averaging around 7.5 for the high consumption (i.e., developed) economies, and varying more widely at lower values of per capita use. In **Figure 35**, a correlation factor starting with the projected 2030 EIA Reference Case ratio of 5.3 and increasing gradually to 7.1 at 7,000 kWh/capita consumption has been used as a suitable approximation for illustrative purposes. Increasing this factor further would imply greater primary energy supply for a given per capita electricity consumption figure. The corresponding ratio for OECD countries in 2003 was 6.7.

Providing Supplies

54. Such dramatically enhanced energy supply requirements raise obvious questions of sustainability, even on the hypothetical assumption that large amounts of additional energy resources could be readily tapped. Accelerated depletion of the world's fossil fuel reserves, the capability of producing countries to vastly expand production and transportation infrastructure, the capacity of developing nations to import much greater quantities of energy while also investing at an unprecedented rate in domestic transformation and distribution facilities, the effect of such increased deliveries on world fuel prices and hence the global economy, the environmental impact of increased burning of fossil fuels, the socioeconomic consequences of related urbanization and industrialization, and the ability of the poorest to pay for much larger volumes of energy even if delivered to their doorsteps are, each in their own right, complex issues as well as formidable obstacles to deviating from business-as-usual scenarios.

55. Alternative resources of energy, such as renewable and nuclear energy, and changes in energy use, such as a transition toward greater efficiency and conservation, as shown in **Section 6**, can only provide a part of the solution, given their existing and predicted low penetration in mainstream energy supplies and the constraints to substantially scaling them up that are becoming increasingly evident. In the long run, transformation of the global economy relying primarily on hydrogen, instead of hydrocarbons, as the energy carrier appears to be the eventual practical goal. However, the timeframe for achieving such seminal shifts in related technologies, markets, and the underlying infrastructure required place them well beyond the immediate future.

4. Energy, Poverty and the Environment

The Micro View: The Poverty Nexus

Income Poverty

56. Poverty, or the lack of access—primarily on account of inadequate income—to basic human needs such as food, shelter, fuel, clothing, safe water, sanitation, health care, and education, has been one of the most inextricable and enduring aspects of human existence. It results not only in a lack of minimum means for human well-being, but also denies choices and opportunities most vital to human development—a long, healthy and creative life; happiness and personal fulfillment; a decent standard of living; self-esteem and the respect of society; chances for self-improvement and intellectual growth; and other things that people aspire for or value in life.

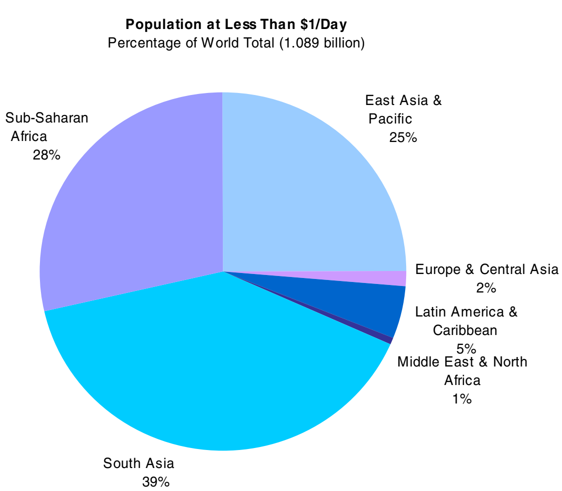
57. Poverty is pervasive in the world, and is present even in the rich, developed nations. However, it is particularly acute and widespread in the developing countries, which contain the bulk of the world's poorest, many of them living in conditions that would be unimaginable in the industrialized countries: roughly 20% of the population of developing countries do not have access to health services; 21% lack access to safe water; 52% lack proper sanitation; infant and child mortality rates are more than five times those in developed countries; per capita health expenditure is one tenth, life expectancy 14 years less, and literacy rates 23% less than that in industrialized nations; the proportion of underweight children is eight times higher; maternal mortality rates are 14 times greater; and the proportion of births not attended by trained health workers is 37 times higher.[14]

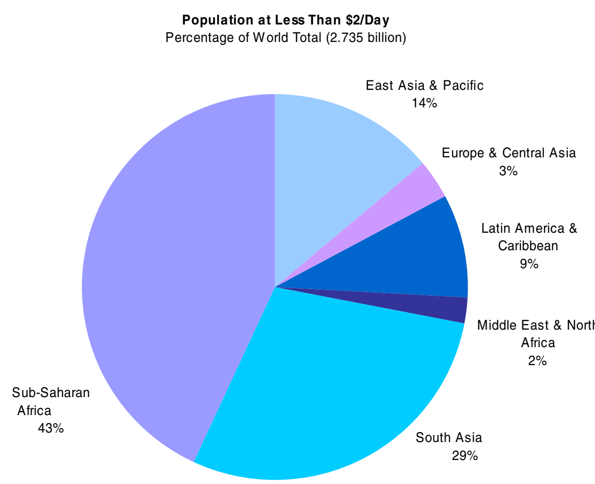
[14] UNDP and World Energy Council (WEC). 2000. *Energy and the Challenge of Sustainability*, p. 44; and World Bank. 2005. *World Development Indicators 2005*.

58. According to the World Bank,[15] almost a half (2.74 billion) of the world's population in 2001 survived on less than $2 a day in terms of equivalent income, goods and services consumed, and a fifth (1.09 billion) on less than $1 a day, with South Asia and Sub-Saharan Africa collectively accounting for as much as 72% and 67%, respectively, of these totals (**Figure 36**). Excluding Central Asia, almost 65% of the world's population living in conditions of extreme poverty (less than $1 a day) in 2001 was Asian. The incidence of poverty in Asia in relative and absolute terms is illustrated in **Figures 37** and **38**, which shows India and the PRC together containing 83% and 77% of those in Asia living below $1 and $2 a day, respectively.

59. Although poverty surveys are difficult to conduct accurately, with results sensitive to the methodologies employed and assessments often being questioned, the scale of the problem is indisputable. A spurt of economic growth in Asia, which is projected to continue into the near future, has helped reduce extreme poverty in several regional countries recently. According to World Bank data, the numbers living on less than $1 a day has declined by 393 million globally in the 2 decades ending in 2001, with 422 million in the PRC alone (but with a large increase in Sub-Saharan Africa). A marked increase in the population living between $1 and $2 has occurred over this period, indicating a decrease in the depth of poverty but not its elimination, and a continuing vulnerability of large numbers of people to relapsing back into absolute destitution as a result of external pressures. Nevertheless, if these trends continue, the "aggregate $1 a day poverty rate for 1990 will be almost halved by 2015, though East and South Asia will be the only regions to more than halve their 1990 poverty rates."[16]

Figure 36: Global Incidence of Poverty, 2001





Source: World Bank (WB). 2005. *World Development Indicators 2005.* Washington, DC: WB.

Energy Poverty

60. Along with the monetary dimension of poverty, energy inputs are a critical determinant of poverty and development. Energy services make possible basic human needs to be met: cooked food, comfortable living temperatures, lighting, use of appliances, piped water and sewage systems, modern health care, educational and communication aids, and swift transportation. Energy is also essential for production, income, and employment generation in

[15] World Bank. 2005. *World Development Indicators 2005.* Washington, DC: WB.

[16] Chen, S., and M. Ravallion. 2004. *How Have the World's Poorest Fared Since the Early 1980s?* Policy Research Working Paper 3341.

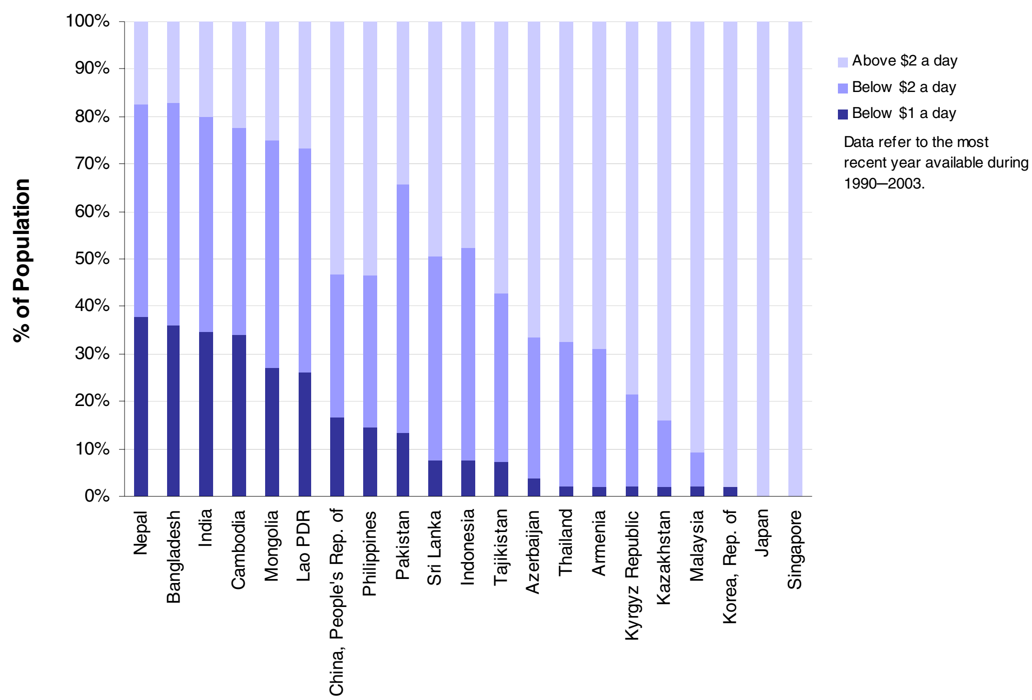
agriculture, manufacturing, commerce, mining, and service industries. The energy dimension of poverty—"energy poverty" can be defined as "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development."[17] While increased access to modern energy inputs does not ensure development in and of itself, its absence can severely curtail the means and opportunities for human and economic growth—universal access to adequate, reliable and efficient forms of energy is therefore a necessary but insufficient condition for development and poverty reduction.

61. The link between energy poverty and income poverty is apparent from the following considerations which are elaborated upon more fully later:

- The poor typically pay more for their daily energy needs in the form of inefficient and potentially harmful fuels, and are therefore less able to accumulate the financial resources to graduate up to efficient fuels or devices that have higher up-front or capital costs.
- Traditional biomass fuels in particular, favored by the poor because of their lower first-use costs, can have deleterious health effects when used indoors, for instance, for cooking purposes and are time and labor intensive to procure and use. Because of its scarcity or inconvenience, biomass users also seldom boil water for drinking purposes. Such fuel utilization can drive up healthcare costs and detract from more productive, income-generating use of available work hours, reducing a household's net disposable income.
- Biomass use can also lead to unsustainable harvesting practices and serious environmental consequences, effects that are more immediately felt by the poor besides also driving up their future fuel costs further.
- Women bear the brunt of inefficient energy use, as they are often the main users of fuel for cooking and invariably responsible for its laborious collection. This not only deprives poor households of potentially one half of their income-earning capability, but also detracts from mothers' vital role in child rearing.
- Children, especially girls, deprived of proper care and often co-opted into fuel gathering, are even more susceptible to poor health as well as being unable to have the time and facilities for education, such as proper lighting, thus greatly reducing their future prospects for gainful employment.

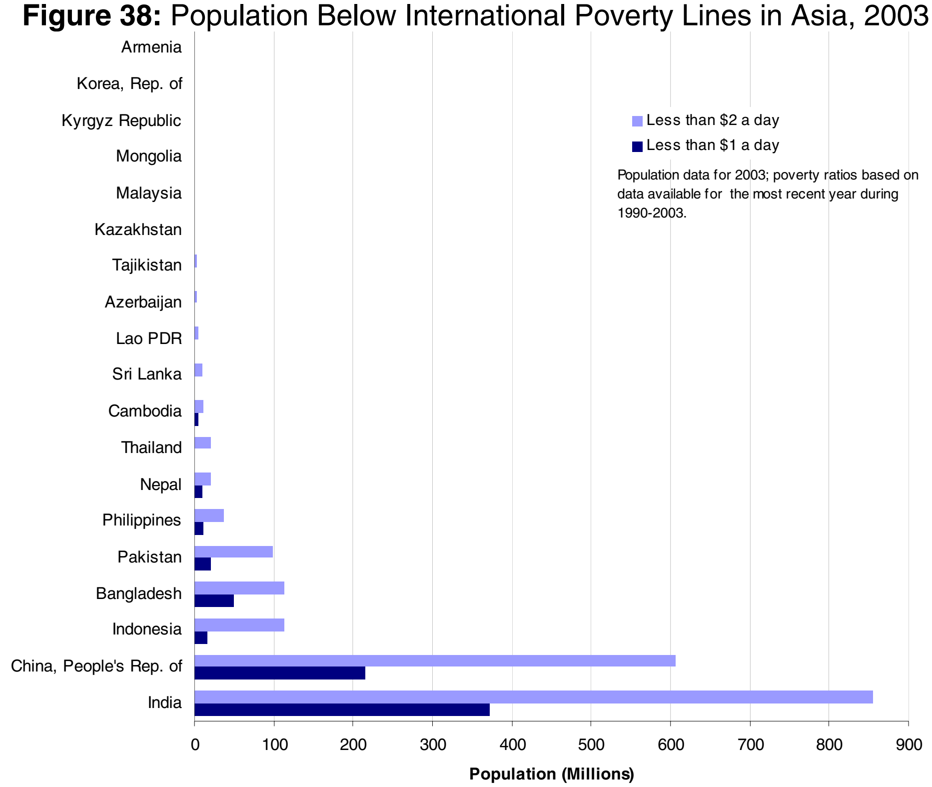
[17] Reddy, A.K.N., and B.S. Reddy. 1994. Energy and Social Issues. In *World Energy Assessment*, p. 44.

Figure 37: Incidence of Poverty in Asia



Lao PDR = Lao People's Democratic Republic.
Source: WB. 2005. *World Development Indicators 2005.* Washington, DC: WB.

Figure 38: Population Below International Poverty Lines in Asia, 2003



Lao PDR = Lao People's Democratic Republic.
Sources: UNDP. 2006. *Human Development Report 2005.* New York: UNDP; WB. 2005. *World Development Indicators 2005.* Washington, DC: WB.

62. The vast majority (86%) of the world's population living with little or no access to modern energy services are the 2.8 billion rural poor in developing countries. As noted, they largely depend on traditional fuels consisting of wood, dung, and crop residues for their basic cooking, lighting, and heating needs. Four out of every five people of the 1.6 billion in the world today without access to electricity live in rural areas, mainly in South Asia and Sub-Saharan Africa. Even the small numbers of the rural poor who do have access to modern energy supplies, such as kerosene, liquefied petroleum gas (LPG), and electricity, invariably can often only afford to use these sparingly because of their higher cost and typically intermittent supply, a situation shared by the urban poor as well. Poor people in developing countries regularly spend up to a third or a quarter of their cash income on meeting their rudimentary daily energy needs. It is therefore not surprising that the incidence of poverty, ill health, and economic distress is also much higher and persistent among the rural population compared with urban dwellers in developing countries.

63. However, because perceived economic priorities and migratory trends often favor urban and industrial growth, this deprived population continues to be subjected to official neglect and disproportionately low levels of energy and development investments in most countries. Indeed, demographic trends are an important consideration in understanding the persistence of energy poverty among the rural poor. The increase in world population from the 2006 level of 6.54 billion to almost 9.1 billion in 2050 will occur almost entirely (99.1%) in the developing countries. By 2030, the developing countries' population will have grown to 86% of the world figure, up from 81% at present, with Asia continuing to account for almost 60% of it. However, the rural population in Asia is expected to remain approximately at the present figure due to rapid urbanization in the region, thereby reducing its share from a third to slightly over a quarter of world population in 2030—but still a significant 2.2 billion people in absolute terms. The large increase in Asia's urban population, which in 2030 will exceed the rural figure, can only be expected to further augment historical, political, and administrative biases against the rural development agenda, reducing the prospects for a renewed emphasis on ameliorating rural poverty, while at the same time increasing the ranks of the urban and peri-urban poor who also have limited energy access. This is further complicated by the onset of epidemics in significant Asian populations, such as AIDS and avian influenza, to which the poor are particularly vulnerable and which can seriously further erode the capacity of the rural population to escape destitution.

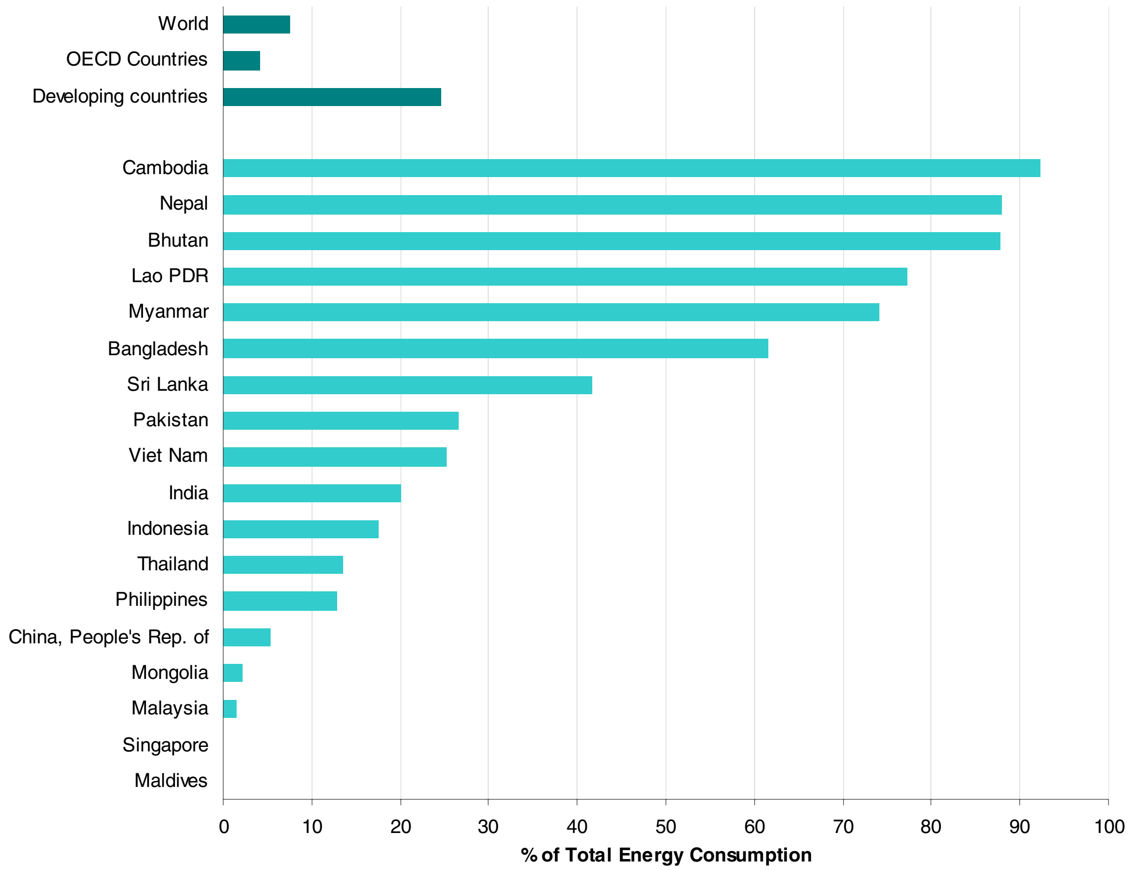
64. Thus, the challenge of rapid human development of the world's poor must clearly focus, in large measure, on increasing access to modern energy supplies for the rural population and on increasing per capita consumption levels for both the urban and rural poor in the developing world. The remainder of this section will explore the role and nature of energy use among the rural and urban poor in more detail, in order to expose its relevance to economic deprivation and environmental degradation—a relationship that invariably results in a self-perpetuating and endemic "poverty trap" for the great majority of the people living in such circumstances.

Inferior Supplies

65. It is estimated that the 2.4 billion poor currently relying on traditional biomass fuels will increase to 2.6 billion by 2030 if present trends continue. **Figure 39** shows the high levels of dependence on traditional fuels in many developing Asian countries. But such traditional energy resources barely help meet minimum standards of living even among the poor who depend on them. While it is estimated that approximately 1,040 MJ of useful energy per capita per year is required to meet basic household cooking, lighting and space heating needs—translating into about 8 to 10 gigajoule (GJ) per capita of primary energy when biomass conversion inefficiency is taken into account—the majority of rural households in Asia fall below even this basic consumption level. Since informal or traditional biomass fuels are collected at little or no

monetary expense outside of the commercial energy market, they usually fall outside national accounts and therefore render the rural energy issue largely invisible. Such data invisibility is another factor contributing to the absence of rural energy supply from development priorities, budgetary allocations, and policy responses.

Figure 39: Traditional Fuel Consumption in Developing Asia, 2002



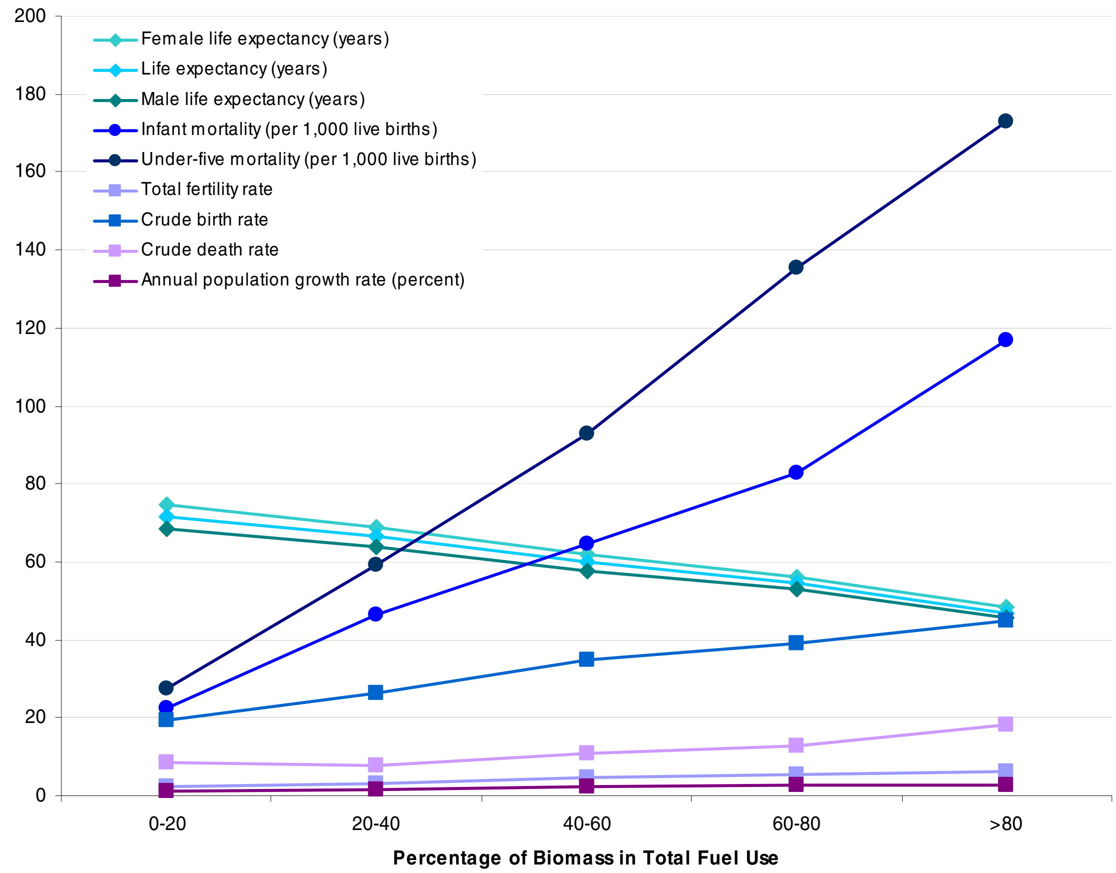
Lao PDR = Lao People's Democratic Republic; OECD = Organisation for Economic Co-operation and Development.
Note: Data for Nepal and Pakistan are for 2001.
Source: UNDP. 2006. *Human Development Report 2005.* New York: UNDP.

66. Traditional fuels also have serious adverse implications that make them a poor substitute for modern energy supplies and further disadvantage the rural populations that rely on them excessively for their needs, while posing grave sustainability concerns as populations rise and the resource base diminishes. In particular, the use of woody biomass helps exacerbate deforestation, with potentially serious environmental costs—deterioration of land productivity and stability, increased instances of flooding and silting of water resources, and the destruction of natural habitats and ecological balance, to name a few—all of which impact the immediate rural setting most severely, in addition to their other downstream consequences. The diversion of crop residues and animal waste for burning rather than soil conditioning or feeding animals can reduce the fertility of land and livestock on which rural livelihoods depend. Biomass combustion in traditional cookstoves results in the release of concentrated air pollutants, such as respirable particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NO_x), and various carcinogenic compounds. Approximately 1.6 million women and children, mostly in rural communities in the developing world, die prematurely from indoor air pollution caused by burning traditional solid fuels in poorly ventilated dwellings, which also causes 40 million new

cases of chronic bronchitis reported each year, as well as less well-documented cases of eye infections, low birth weight, and cancer. The time and energy spent in collecting, storing, and using traditional fuels is a considerable drain on human productivity, especially among women and children, which could instead be spent on more economically or intellectually gainful tasks. This has direct implications on infant care and child rearing, education and literacy, gender development, and the ability of rural households to engage in increased and higher income-generating activities. Finally, the lack of modern energy substitutes precludes the restructuring of rural economies that would be necessary to enable them to participate more fully in mainstream economic activities and employment opportunities, and thus help alleviate poverty on a wider scale more rapidly.

67. The discussion above suggests an inverse correlation between traditional biomass use and desirable demographic indicators, especially for women and children who are considered to be the most vulnerable. An example of such a correlation is shown in **Figure 40** which, although not a proof of causality, underlines the observed consequences and assumptions consistent with such biomass fuel use. Additional such negative relationships between biomass use and social indicators, such as child malnourishment, school enrolment ratios, female employment, maternal health, healthcare expenditures, and environmental factors, such as deforestation, that have a direct bearing on sustainable human development can be surmised, although a detailed analysis is currently not available.

Figure 40: Biomass Use and Demographic Indicators



Source: UNDP and World Energy Council (WEC). 2000. *Energy and the Challenge of Sustainability.* New York: UNDP and WEC.

Rural Demand

68. The main characteristics of rural energy use need to be understood before attempting to devise appropriate strategies for helping the indigent break out of the vicious cycle fueled by such energy poverty: unsustainable and unproductive energy use that saps the fecundity of the sustaining environment, perpetuates economic privation, and undermines the already feeble endogenous capacity of the poorest to overcome debilitating poverty, disease, and illiteracy.

69. In rural settings of the developing world, households are the major energy consumers, accounting for roughly 85% of total use, comprising mostly of traditional fuels for cooking and heating. Depending on the level of mechanization, agricultural use accounts for 2%–8% of the total energy consumption (excluding human and animal power), mainly in the form of commercial energy (diesel and electricity) to power farm equipment and water pumps. Kerosene and electricity, where available, are principally used for the 2%–10% energy required for lighting purposes, while a much smaller fraction of the latter powers small household appliances. This pattern usually presents challenges in rural electrification projects, which have to be able to meet relatively high peak loads for small durations (e.g., evenings), while the overall demand profile remains uneconomically low for the rest of the day. Rural industries, at the cottage and village level, consume less than 10% of the aggregate rural energy demand in most developing countries, typically in the form of electricity and biomass (wood and crop residues).

Environmental Linkages

70. In addition to rapid population growth in conditions of economic stagnation, poverty levels are greatly exacerbated by environmental degradation. As mentioned, unsustainable biomass harvesting for energy production denudes rural landscapes of available foliage cover, accelerates deforestation, and diverts organic matter away from conditioning the soil and feeding livestock. This in turn reduces agricultural productivity and incomes because of lowered yields and more frequent crop failures, reduces land value due to erosion and loss of fertility, and degrades water resources through soil runoff and loss of retentive capacity. The resulting loss of rural livelihoods forces the poor to migrate to urban centers in search for employment, often with ill-suited skills that only help increase the ranks of the urban poor and result in increased environmental pressures on already strained urban resources. Similarly, settlements tend to move into coastal and forested areas in search of better resources, greatly threatening their fragile ecosystems. As these lands become denuded and further marginalized, the condition of the poor migrants worsens, and they have to resort to occupations of decreasing productivity that only deepens their poverty. The fragility of marginal rural lands in Asia has caused the numbers of the landless rural poor to increase substantially, making the problem of alleviating their poverty even more intractable.

71. These linkages between poverty and environmental degradation have been postulated for some time.[18] Empirical observations seem to suggest that a number of indicators of environmental quality first deteriorate and later improve as per capita incomes rise. This inverted U-shaped pollution-income trend is termed the "Environmental Kuznets Curve (EKC)" (**Figure 41**), after the similar relationship between income distribution and per capita income identified by Simon Kuznets in 1955. It can be explained by the assumption that unfettered economic development is intrinsically detrimental for the environment, so that as poor countries develop, they place an increasing burden on their physical and ecological resources. However, as nations become wealthier (and environmental concerns become more prominent and tangible), they are willing and able to devote a part of their incomes to cleaning up some of the

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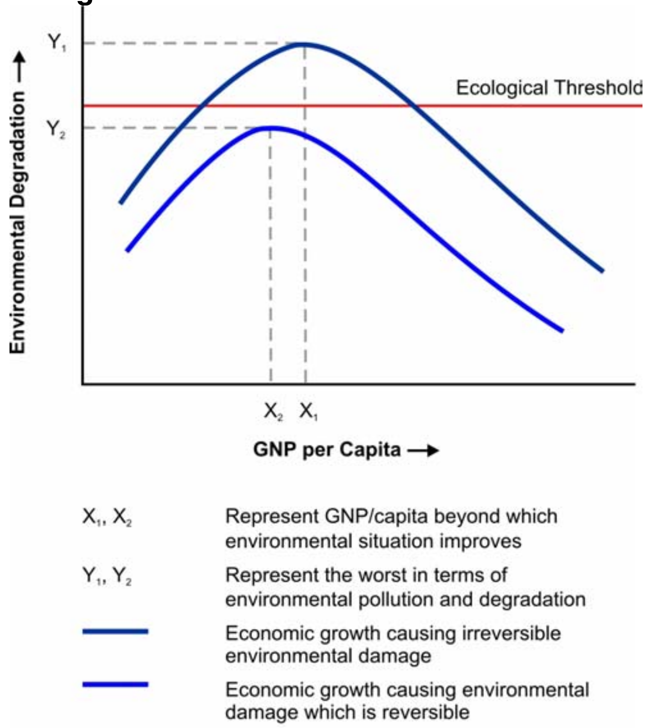
[18] Formally stated, for example, in the Brundtland Report of the WCED in 1987 (World Commission for Environment and Development. 1987. *Our Common Future.* World Commission on Environment and Development Report).

impacts of growth, thereby helping reverse the decline.[19] As anecdotal evidence, the case of urban pollution can be cited: while the large cities of Asia continue to suffer from deteriorating environmental conditions as they grow, their more developed counterparts in the industrialized world are today much cleaner than they were, say, 20 years ago.

Figure 41: Environmental Kuznets Curves



GNP = gross national product.

72. More rigorously, a Kuznets relationship has been reported between per capita income and, *inter alia*, specific environmental parameters: emissions of sulfur dioxide (SO_2), particulates, NO_x and CO, carbon dioxide (CO_2), chlorofluorocarbons (CFCs); various indicators of water quality, including faecal coliform, biological and chemical oxygen demand (BOD and COD) and arsenic; and deforestation.[20] Based on such analysis, it has been concluded by several researchers that developing countries will automatically become cleaner as their economies grow. Others have argued the inevitability of the poorest countries to become more polluted as they develop. Still others have concluded that while some of environmental indicators may indeed follow such a deterministic inverse U-shaped EKC, others (especially pollutants with non-local effects) may not, and that some of the initial damage done may remain permanently irreversible.[21]

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[19] The "turning point" in environmental quality has been reported to typically occur from $3,000 to $8,000 per capita income (Jalal, K.F. 1993. Sustainable Development, Environment, and Poverty Nexus. ADB *Occasional Papers No. 7*, pp. 15–19; and Harbaugh, W.T., and A. Hammond. 2002. Reexamining the Empirical Evidence for an Environmental Kuznets Curve. In *The Review of Economics and Statistics.* Vol. 84, No. 3, p. 2. August).

[20] For a review of relevant sources, see Barbier, E.B. 2001. Introduction to the Environmental Kuznets Curve, *Environment and Development Economics.* Vol. 2 (4) Special Issue.

[21] For example, see Dasgupta, P. 2003. World Poverty: Causes and Pathways. In Proceedings of the World Bank Conference on Development Economics 2003 and Harbaugh, W.T., and A. Hammond. 2002. Reexamining the Empirical Evidence for an Environmental Kuznets Curve. In *The Review of Economics and Statistics.* Vol. 84, No. 3.

73. While the degree to which poverty and environmental degradation exacerbate each other may be the subject of continuing debate, several important conclusions can nevertheless be drawn about the nexus. First, that poor, developing countries do not normally have the additional resources, financial or technical, to ensure clean development, and therefore suffer potentially avoidable adverse environmental consequences of their growth. Second, that the local environmental impacts of such development—industrial and vehicular emissions, water pollution, land degradation, deforestation, etc.—affect the poorest directly and can often increase economic stress on them. Third, that while, in the long term, conditions may eventually improve, the turning point in the EKC may come at much elevated levels of income—i.e., much later in the development cycle—or not at all. Therefore, effective environmental protection strategies adopted at the outset would not only insulate the most vulnerable from additional poverty pressures, but would also carry long-term implications for the sustenance of natural resources—at least to the degree that some of the potential losses may not be temporary but inherently irrecoverable (i.e., the peak of the EKC curve may lie above the ecological threshold, as for the upper curve in (**Figure 41**). It may also be the case that developing countries could bypass some of the more polluting paths of economic growth by resorting earlier to cleaner, efficient technologies or fuels, thereby reducing the environmental footprint of their development activities. For instance, it is noted later that several developing countries currently have a higher level of renewable energy supply (particularly hydro, but also increasingly wind) in their national energy mix compared with many developed countries at equivalent stages of their growth. In such instances, their relevant Kuznets curves may peak earlier or flatten somewhat.

74. However, these lessons are not entirely understood or uniformly interpreted, and their implications can be significant. Many of the fastest developing economies, mostly in Asia, have taken the EKC message as a rationale for allowing development to override the environment, as the “cleaning up” will happen eventually anyway. Furthermore, if the EKC model is correct, the scale of the pollution threat facing developing countries is formidable. According to the World Bank, the average per capita GDP in 2002 was $449 in 59 low-income countries and $1,786 in 52 lower-middle income countries.[22] These countries are thus far from the mean peak pollution point on the EKC curve of $5,000, and apparently condemned to endure increasing pollution levels and natural resource depletion for decades to come. Moreover, empirical data indicate that pollution costs in these countries are already at alarming levels. For example, World Bank estimates of mortality and morbidity from urban air pollution in India and the PRC suggest annual losses in the range of 2%–3% of GDP.[23] Under the Kuznets environmental hypothesis, the prospects for developing Asia, therefore, could be extremely dire.

75. Apart from the impact of development and the environmental damage on local air and water quality, ecosystems, rural livelihoods, and the sustaining capacity of agricultural lands as a consequence of an over-reliance on traditional biomass fuels, the use of modern energy brings with it its own set of macro and global issues, especially as a result of the worldwide consumption of polluting fossil fuels. These impacts, and their effect on the poor, are discussed separately later in the next section.

Affordability and Use

76. The composition of energy use varies significantly across different geographical areas as well as environmental and climatic conditions. Consumption patterns have also been observed to be greatly influenced by income levels, with the poorest consuming almost all energy for cooking and those progressively better off using increasing proportions for lighting,

[22] In constant 1995 US dollars.

[23] Dasgupta, S., K. Hamilton, K. Pandey, and D. Wheeler. 2004. Air Pollution During Growth: Accounting for Governance and Vulnerability. Policy Research Working Paper 3383, pp. 2-3.

water and space heating, refrigeration and cooling, and recreational needs, roughly in that order. Per capita energy consumption may also initially drop as incomes rise and the use of more efficient fuels and appliances becomes possible. Besides fuel availability and costs, personal and cultural preferences can also strongly influence energy choices and consumption patterns, even among the poorest, particularly for cooking and lighting where convenience and quality perceptions are often paramount. Thus, household choices among energy carrier options are influenced by economic considerations as well as attitudes and the attributes of the available alternatives, with income being the main determinant.

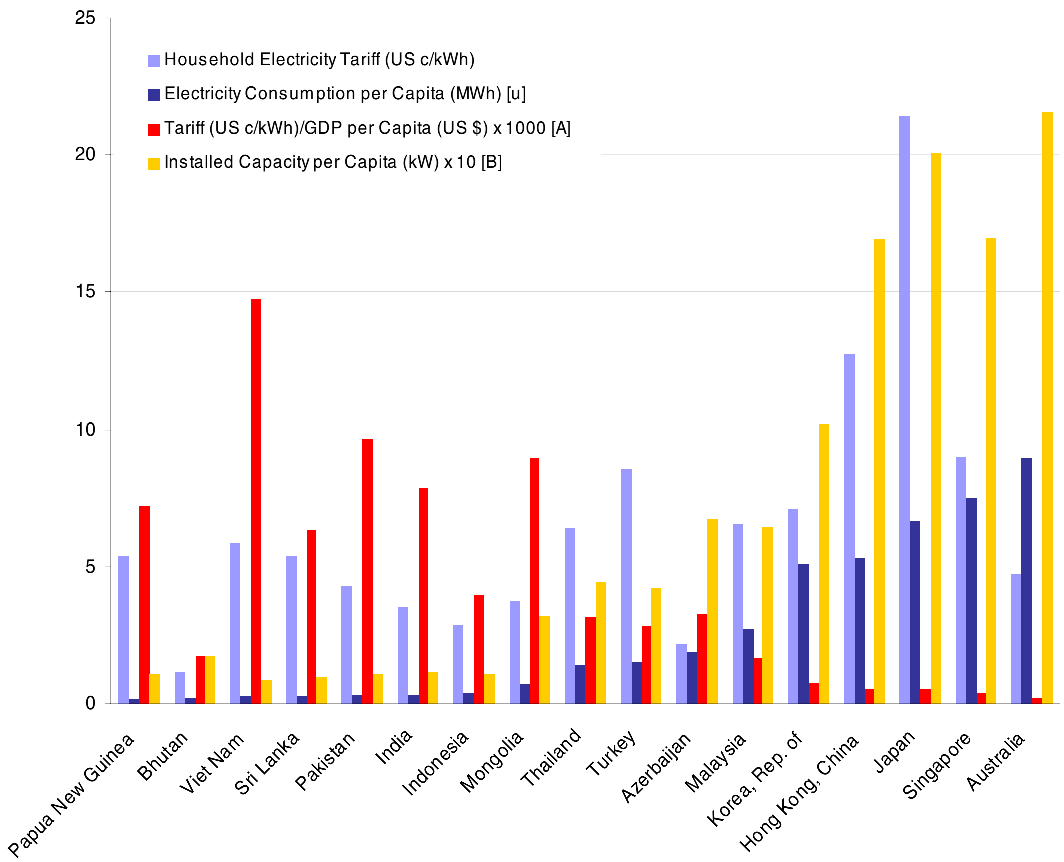
77. The additional economic and financial considerations affecting energy use include the fixed and variable components of fuel cost. These can be further influenced by service charges (e.g., monthly charges for electricity and gas connections), lump sum payments for bulk fuel purchases, and the need for up-front security deposits or equipment payments (e.g., for LPG cylinders). A household's liquidity and wealth dictates the division between these cost elements and its readiness to forgo present consumption in favor of future benefits—e.g., a household with low income and high costs of borrowing or diverting amounts or from other needs may be unwilling or unable to finance the up-front capital costs of efficient energy, even if the inferior alternative has higher lifecycle costs. Since modern energy services and efficient devices usually involve higher initial costs, the poor inevitably end up with less efficient energy choices that have harmful side effects as well as high opportunity costs of labor and time involved in collection activities.

78. Therefore, energy use by the poor in developing countries represents a precarious balance between meeting basic survival needs, largely through recourse to cheap or "free" traditional fuels. Most poor seem to aspire for greater access to commercial energy supplies as their incomes allow but which, on the whole, remains persistently well below the levels required to substantially improve per capita consumption rates. Improved energy supplies and devices that ensure greater efficiency of use, on the other hand, can translate into substantial increases in the purchasing power of the poor. Studies have shown that such an increase in available resources among low-income groups would almost entirely be spent on better satisfying basic needs for food, shelter, clothing, health, education, and additional fuel. Cost-effective improvements in energy supply can thus have powerful poverty reduction consequences.

79. The issue of affordability of modern energy supplies perhaps lies at the heart of the problem. Without such means, there cannot be adequate levels of demand to make the necessary supply infrastructure economically viable, which in turn shields such deprived communities and individuals from reasonable opportunities for personal development and economic betterment. The case of electricity is a particularly pertinent one, as electrification is considered a *sine qua non* of modern human existence and all forms of economic and industrial activity, and as its direct relationship with human development indices, examined earlier, demonstrates. **Figure 42** shows data for selected countries in the Asia and Pacific region for 2000, comparing per capita electricity consumption in these countries with their average household electricity tariffs. While it is not surprising that per capita electricity use is the lowest—and well below the 4,000 kWh/capita threshold discussed earlier—in the least developed countries and rises to twice this level for higher income countries, it can be seen that this bears little relationship to nominal retail tariffs in these countries (e.g., Singapore's per capita use in 2000 was 27 times that of Sri Lanka with similar climatic conditions, although the tariff in the latter was 40% lower). A more interesting relationship emerges if the tariff is taken as a proportion of the average per capita income (or GDP): in this case, as the cost of electricity in proportion to average income decreases (calculated in nominal terms, multiplied by a normalization factor, and shown as red bars in the figure) across the countries from the left to the right, the per capita electricity consumption (dark blue bars) increases.

80. The two outliers in **Figure 42**, Papua New Guinea and Bhutan, indicate that factors other than price affordability might also be at work here. One obvious additional constraint is the availability of electricity for all, regardless of its price. Indeed, the installed capacity per capita (yellow bars) in these countries shows that this would indeed be expected to reduce average per capita consumption figures in the low-income countries where the generation (and corresponding distribution) infrastructure is grossly inadequate (and latent, unmet demand high), while for the more affluent countries on the right of the diagram this would not present a determining factor as electrification coverage is universal (i.e., zero unmet demand). It can thus be seen that Japan, even with consumer electricity tariffs that are from 1.5 to almost 60 times those in the other countries shown, can have one of the highest rates of per capita electricity use because of its correspondingly high per capita income levels, while the less developed countries grouped on the left face uniformly high "affordability" barriers, represented by the red bars, as well as serious supply shortages, represented by the yellow bars. In other words, the negative elasticity of electricity consumption with respect to tariffs as a proportion of income is much higher than that with respect to absolute tariff levels alone.

Figure 42: Household Tariffs and Per Capita GDP and Electricity Consumption in the Asia and Pacific Region, 2000

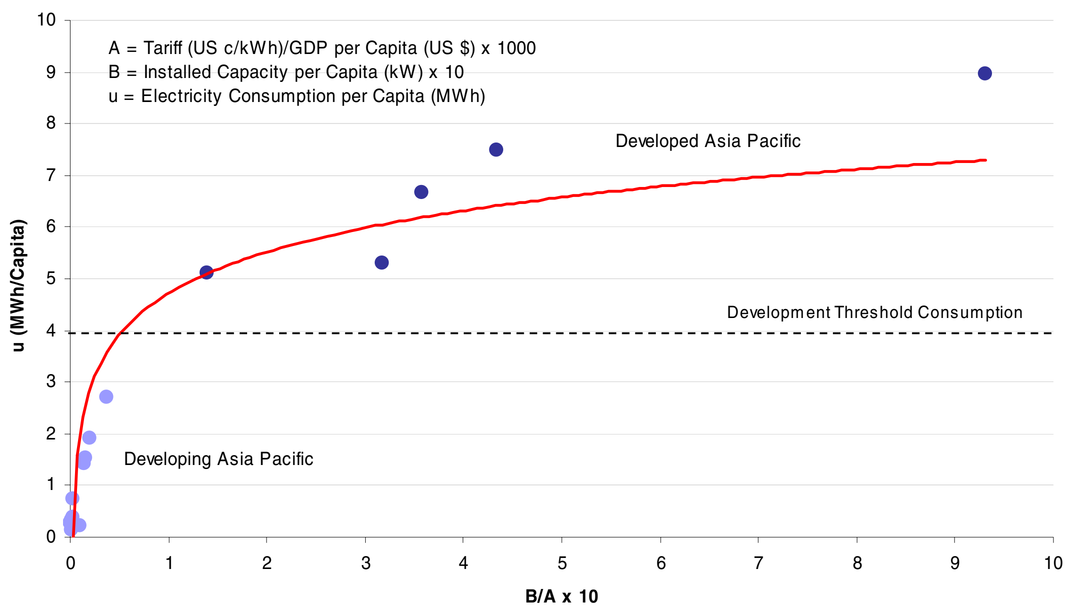


c/kWh = cost per kilowatt-hour; GDP = gross domestic product; kW = kilowatt; kWh = kilowatt-hour; MWh = megawatt-hour; US = United States.

Sources: US DOE/EIA. 2006. *International Energy Outlook 2006.* Report # DOE/EIA-0484 (2006). Washington, DC: EIA, US DOE; UNDP. 2002. *Human Development Report 2002.* New York: UNDP; United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). 2001. *Electricity and Sustainable Development in Asia and the Pacific.* Bangkok: UNESCAP.

81. The combined affect of affordability and availability of electricity may be visualized better by multiplying installed capacity per capita by the inverse of the "proportional" tariff (as the two are expected to push per capita consumption in the same direction), and plotting the value for each country shown against its per capita electricity consumption, as shown in **Figure 43**. Here a distinct correlation is evident supporting the assumed relationship between electricity availability, affordability, and use. Indeed, for the five countries above the "development threshold" of 4,000 kWh/capita shown in the diagram in dark color (the Republic of Korea; Hong Kong, China; Japan; Singapore; and Australia), each with 100% electrification rates in 2000, it may be asserted that price affordability is the primary determinant of per capita electricity consumption levels.

Figure 43: Correlation between Electricity Use, Tariffs, and Installed Capacity for Selected Asia-Pacific Countries, 2000



GDP = gross domestic product; kW = kilowatt; kWh = kilowatt-hour; MWh = megawatt-hour; US = United States.
Sources: US DOE/EIA. 2006. *International Energy Outlook 2006.* Report # DOE/EIA-0484 (2006). Washington, DC: EIA, US DOE; UNDP. 2002. *Human Development Report 2002.* New York: UNDP; UNESCAP. 2001. *Electricity and Sustainable Development in Asia and the Pacific.* Bangkok: UNESCAP.

Raising Consumption

82. Perhaps even more importantly, the enormity of the task facing Asia's developing nations can be gauged from their clustering (shown in light color) at the extreme lower end of the trend curve shown, where even the most advanced among them (Malaysia) remains well behind the lowest among the developed five (the Republic of Korea). The challenge for these countries is not just to extend their electricity networks to their entire populations and add incremental generation capacity as required—a formidable task in its own right given their large population base and limited financial means—but equally critically to increase national incomes rapidly enough (especially with respect to power tariffs) for their people to actually be able to leverage improved electricity access in a meaningful manner that helps bring their HDI measure closer to the desired 0.9 benchmark within a reasonable timeframe. However, as in the HDI versus electricity consumption curve in **Figures 32** and **33**, the dividends of even small improvements in the enabling factors (in this case, electricity affordability and availability) can

have a dramatic impact in the associated benefit (in this case, per capita electricity consumption).

83. Thus, at least until the threshold consumption level of 4,000 kWh/capita is attained, developing countries can reap large development benefits from investments in enlarging their energy infrastructure utilizing an optimum combination of least-cost supply options. Nevertheless, the importance of overall economic development and income growth that would enable actual increase in per capita energy use cannot be overemphasized. Slow GDP growth, persistently large income disparities among the population, and high consumer energy prices, particularly of electricity, would continue to keep the existing large numbers of the energy poor in these countries deprived of the benefits of modern energy and opportunities for development, regardless of any overall improvement in the energy supply situation that may occur in the meantime.

84. Furthermore, their susceptibility to chronic poverty, and particularly their lack of ability to withstand economic shocks, could well increase due to the global consequences of persisting with current patterns of energy use, as described next.

The Macro View: Global Impacts

Energy Prices

85. Energy prices impact development and growth prospects at the global level in a way by which the poorest are most directly affected. For instance, recent increases in oil prices have affected poverty indicators across many developing countries—in some cases increasing the proportion living below the poverty line by as much as 6%. At the macro level, increased oil import expenditures have, for some countries, consumed as much as 3%–10% of their GDP. Such an increased financial burden not only hurts the domestic economy by raising the costs of production and living, decreasing export competitiveness, and reducing the returns on developmental investments—all factors that hit the poor directly and most severely—but also greatly reduces the already meager resources available in developing countries for basic social and human development programs.

Climate Change

86. The climate change implications of the current global fossil fuel-dependent energy system further compound existing poverty conditions and increase the vulnerability of the poor to the resultant impacts. Both because of their more direct exposure to nature and its extremes (such as droughts, heat and cold waves, storms and heavy rainfall) as well as their greater dependence on natural resources (crops, livestock, biomass fuels, etc.), the rural poor, in particular, remain extremely susceptible to the short- and long-term changes brought about by global warming and associated effects on weather patterns, pestilence, incidence of disease and epidemics, and productivity of land and water resources, to name a few.

87. Asia's vulnerability to climate change is dictated by its unique physical and socioeconomic attributes: high population density, relatively low economic development, and the prominence of agriculture and fishing in providing livelihoods. Surface water and groundwater resources in Asian countries are critical for forestry, agriculture, fisheries, livestock production, and industrial activity. Agriculture and water sectors are considered to be the most sensitive to climate change impacts in Asia, the severity of which would be amplified by the large numbers of the relatively poor who are most directly dependent on them. Mountainous communities, habitats, and ecosystems would be affected by the melting of glaciers and permafrost regions, which would suffer from increased runoff and landslides. The frequency and severity of flooding is also expected to increase in downstream riparian regions, while the large arid and semi-arid tracts of Asia will come under growing water stress. Glacial melting will increase river flows and

flooding initially, leading to years of reduced flows as the ice disappears. Mangrove and coral reefs, along with their complex ecological systems, would come under tremendous threat from sea level and temperature changes. Countries would have increased exposure to extreme events, including forest die-back and increased fire risk, typhoons and tropical storms, floods, and severe vector-borne and infectious diseases.

88. Agricultural losses in Asia are expected to be severe on account of high temperatures, extreme drought, flooding, and soil degradation, making food security a major issue for many countries, especially their poor. Crop production and aquaculture would be affected by the combined effects of thermal and water stresses, sea-level rise, increased flooding, and strong winds associated with intense tropical cyclones. The monsoons in tropical Asia could become more variable if El Niño-Southern Oscillation (ENSO) events become stronger and more frequent in a warmer atmosphere. Productivity of fish could be affected by large-scale changes in marine populations, and sea level rise would cause massive inundation along the continent's vast, articulated and heavily inhabited coastline, resulting in displacement of large populations. Disruption in water supplies, ecological systems, and natural response mechanisms caused by systemic climatic variations may also increase the prevalence of diseases such as cholera, dysentery, malaria, and dengue fever, further reducing the ability of poor communities to make ends meet.

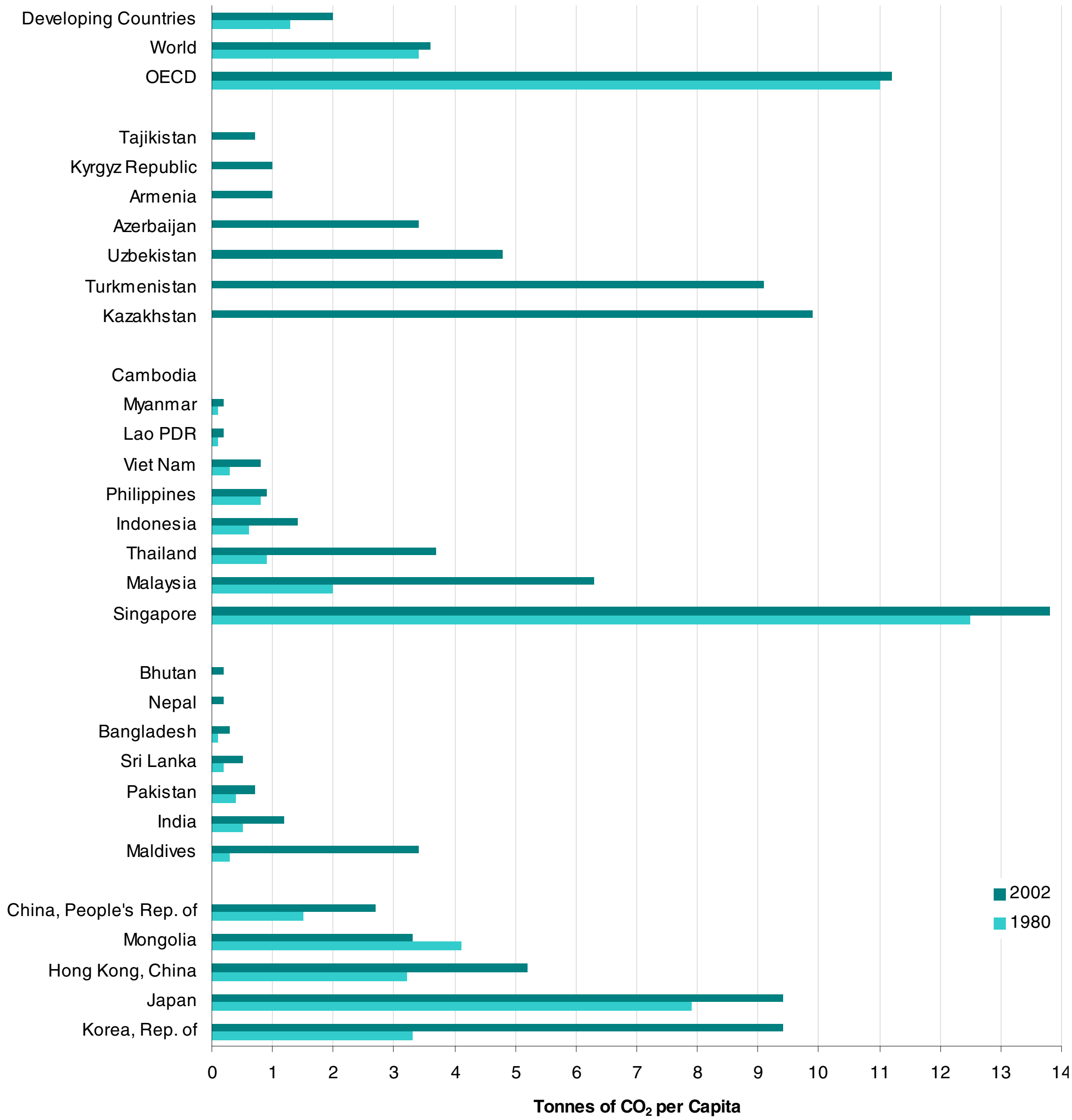
89. In particular, for the subsistence dryland, non-irrigated agriculture practiced by a large number of Asian rural poor, even small changes in average temperature or precipitation could have disastrous consequences on outputs and thereby erode their incomes, nutrition levels, quality of health care, and ability to access formal education. Coastal fishing and farming communities would likewise be severely impacted, in terms of both potential livelihood and habitat loss, by sea-level rise and saltwater intrusion into inland waterways and productive lands.

90. According to the EIA, worldwide CO_2 emissions are expected to increase by 1.9% annually from 2001 to 2025. Much of the increase in these emissions is expected to occur in the developing world where emerging economies, such as the PRC and India, fuel economic development with large-scale use of fossil energy. Developing countries' emissions are expected to grow above the world average at 2.7% annually between 2001 and 2025, and surpass emissions of industrialized countries near 2018. Although currently per capita greenhouse gas (GHG) emissions in Asia are low compared with world and OECD averages (**Figure 44**), they are growing rapidly and are significant in terms of absolute volume. For instance, the PRC is already the largest emitter of GHGs in the world after the US. Additionally, GHG emissions per unit of GDP, or carbon intensity, in developing Asia is twice the level in the developed countries. This situation is likely to persist over coming decades, even as intensity levels decline gradually in all countries. Asia is thus poised to become one of the biggest contributors to global warming in the not too distant future.

91. In addition to its global warming impacts, the combustion of fossil fuels can rapidly degrade the local environment, especially air quality. Presently, two thirds of acid rain deposition in the Asia and Pacific region is caused by outdated pollution controls in coal-fired power plants in the region. About 60% of Indian power production is based on low-grade local coal with over 40% ash and high sulfur content. Other countries, such as the PRC, Indonesia, and Pakistan are either already highly dependent on coal or are contemplating switching over to its increased use in the face of rising oil prices. Rampant oil and coal use, industrial emissions, and biomass burning have caused extensive smog and haze over many Asian cities, such as the infamous Asian Brown Cloud stretching over large portions of Southeast Asia. Increased acid rain is also projected, with baseline sulfur emissions estimated to increase from 33.6 million tons in 1990 to over 110 million tons by 2020, a 230% increase. The adverse effects of such pollution on

human health and productivity are once again, felt most severely by the region's poor who have little or no defenses against them.

Figure 44: Per Capita Carbon Dioxide Emissions in Asia, 1980 and 2002



CO_2 = Carbon Dioxide; Lao PDR = Lao People's Democratic Republic; OECD = Organisation for Economic Co-operation and Development.

Source: UNDP. 2006. *Human Development Report 2005.* New York: UNDP.

92. Climate change and environmental pollution would thus represent a major additional dynamic that could bring about wide-scale changes to existing environmental and ecological balance, and thereby exacerbate poverty conditions, especially among the 70% of the world's poor who live in rural areas. Increasing investments in energy supplies, rising average incomes among the poor, and higher per capita use of modern energy services are all objectives that could be directly and, in many cases, severely, diminished by the climatic consequences of increased greenhouse gas emissions from the burning of oil and coal. Greater energy production, as long as it remains predominantly based on fossil fuels—which, as discussed in

Part I, it is expected to for the next quarter century at least—would therefore result in inequitable per capita consumption rates between the world's rich and poor being further accentuated, and increase the cost and difficulty of raising substantial populations out of the inexorable energy-poverty-environment nexus.

Management Issues

93. Another aspect of the current energy system at the macro level relates to its management. The emphasis of energy policy in developing countries tends to focus on commercially traded forms of energy—such as electricity, coal, gas, and petroleum products—of which the prime beneficiaries are urban dwellers and industry. It has already been noted that the non-commercial nature of traditional biomass fuels obscures them from national-level accounting and planning, which in any case is usually predisposed in favor of the wealthier, urban segment of society where such decision-making tends to be concentrated in the first place. The recent worldwide upsurge in interest in renewable energy has also, for example, been spurred by the emerging commercial-scale competitiveness of some of the technologies involved, albeit with appropriate environmental subsidies, against other grid-connected electricity generation options, rather than by the proliferation of large-scale, low-cost dispersed power and heating systems as an alternative resource for poor communities and households. For the less commercially attractive energy needs of the poor, therefore, greater planning and management resources would need to be devoted to rural energy supply networks and distributed, off-grid power generation to counter existing market bias toward urban energy services.

94. The fact that traditional biomass fuels usually do not fall under the purview of a single ministry, and that coordination between agencies responsible separately for relevant but diverse areas such as energy, agriculture, forestry, rural development, and environment, is generally weak in developing countries—especially when it comes to realizing the interaction between rural energy use, environmental denudation, sustainable livelihoods, and human development—helps perpetuate a lack of appropriate attention and inaction toward improvements in rural energy and traditional fuel use. Improvement in administrative structures and mechanisms to ensure greater coordination between these agencies and a better, shared understanding among them of rural energy needs would be required to provide a more effective institutional framework through which suitable support could be channeled. A consolidation of some institutions and functions alone can sometimes help remove unnecessary bottlenecks and fragmentation of responsibilities and thereby achieve greater effectiveness, often at lower cost.

Market Bias

95. The market trends and restructuring brought about by an increasingly globalized and competitive world economy, such as privatization, commercialization, and deregulation, are expected to significantly influence the efficiency and scale of energy production and delivery, as well as its cost to the end-user. While open-market competition and technological innovation would help lower costs of energy production, reduce corruption and losses, and improve infrastructure and access, in many cases the withdrawal of state monopolies and subsidies could also drive up tariffs and prices, especially for the erstwhile subsidized poor. Therefore, replacement of old, inefficient subsidy structures whose benefits were often reaped by the relatively well-off by rationalized prices based on actual cost of service provision, augmented by smart subsidy support for the deserving poor, is an area that requires serious thought in most developing countries.

96. In addition, increasingly commercialized energy investments would also tend to favor economically attractive urban and industrial customers rather than the marginalized poor with their comparatively modest purchasing capacity and needs. Often, expansion of the power

network in developing countries for purposes of rural electrification, for instance, is mandated by the state as a socially desirable objective rather than on the basis of economic viability, and such grid extension would be difficult to continue purely on considerations of profit. Another example is renewable energy systems for decentralized rural energy supply, which typically require up-front capital support and subsidies in order to make them affordable to the poor and, therefore, are often inherently not commercially feasible.

97. On the other hand, public resources freed up as a result of state withdrawal from the commercial energy sector could be more effectively channeled to areas that need direct outside intervention and support, such as methods for increasing energy access for the poor. Therefore, the entire question of how to increase access to modern energy supplies for the poor under such changing market conditions would need to be examined afresh, and new methods found to offset some of the potentially adverse implications for the already energy-deprived. Empirical evidence to help guide such a reassessment is, unfortunately, still too sketchy and insufficient to offer much confidence in the emergence of effective preemptive strategies in the near future.

5. Energy Services and the Millennium Development Goals

98. The Millennium Development Goals (MDGs) reflect an international undertaking to significantly improving the condition of the world's poorest by 2015. Eight specific MDGs were drawn from the actions and targets contained in the Millennium Declaration[24] adopted by 189 nations during the UN Millennium Summit held in September 2000:

Goal 1: Eradicate extreme poverty[25] and hunger
Goal 2: Achieve universal primary education
Goal 3: Promote gender equality and empower women
Goal 4: Reduce child mortality
Goal 5: Improve maternal health
Goal 6: Combat HIV/AIDS, malaria and other diseases
Goal 7: Ensure environmental sustainability
Goal 8: Develop a Global Partnership for Development

99. These goals have been further broken down into 18 quantifiable targets to be tracked through 48 indicators. Although aimed at improving the human condition in countries that are lagging behind on the HDI scale, none of the MDGs, targets or indicators explicitly refer to the supply of modern energy services as a direct and quantifiable means for improving living conditions, social well being, growth opportunities, and poverty reduction of the poor. Reference to energy consumption appears only as a means for lowering energy intensity (apparent consumption in oil equivalent per PPP unit GDP produced) to help improve environmental sustainability objectives under Goal 7.

100. However, it is important to understand that without adequate supplies of quality, reliable, and affordable modern energy, the MDGs cannot be met, and that such energy services are in themselves an intrinsic feature of a developed society—i.e., high overall development indicators that do not rely on correspondingly high energy consumption are not possible—and are, therefore, an essential goal in itself. In fact, reliable modern energy supply is more than an economic convenience; it provides unique benefits of physical comfort, stimulates intellectual development, and enables the growth of human capital—which in turn can facilitate economic betterment and income growth. The pleasure of a well-lit, suitably conditioned home or

[24] United Nations Millennium Declaration, General Assembly Resolution 55/2, 8th Plenary Meeting, 8 September 2000.

[25] By reducing by half the population living on less than $1 a day.

workplace, of instant telecommunications, of rapid transportation, and of labor-saving appliances, to name a few, is equally as essential as, for instance, the joy of acquiring knowledge or the availability of good health care. Thus, if the latter are deemed worthy MDGs, then an equally persuasive case can be made for access to affordable modern energy services.

101. Both aspects of the relevance of energy services to the MDGs are important. It would therefore be illuminating to first examine how energy services underpin the attainment of specific MDGs[26] before concluding, in **Part III**, on ways in which the provision of energy can be more formally and unambiguously recognized in the development priorities of Asian nations.

Growth and Income Poverty Reduction (Target 1)

102. Modern energy services help raise agricultural and labor productivity as well as providing new income generating opportunities, resulting in income and economic growth. Electric lighting can extend such activities beyond daylight hours and, along with other fuels, power labor- and time-saving mechanization. Additional value addition and revenue-earning options thus made possible can help diversify and expand income sources, increase the scope of local employment and levels of skill development, and improve the capacity of the poor to overcome economic setbacks and challenges, allowing them to move away from the margins of poverty instead of chronically falling back into it. The unit cost of energy consumed also decreases with modern forms of supply and use versus traditional methods, both because of their increased efficiency as well as the reduced effort required for access, thereby allowing a greater proportion of income to be used for other basic needs which can then be better satisfied. Finally, modern energy makes possible most of the economically vital activities and services upon which technologically developed societies depend and flourish—industrialization, high speed transportation, telecommunications, information technology, personal work and lifestyle aids, etc.—none of which can function on traditional fuels. Denying people access to modern energy is thus equivalent to depriving them of the fruits of human economic and technological progress in virtually all fields. Instead, it confines them and their future generations to a low-yield, labor-intensive life and denies them the means and tools to raise incomes and escape perpetual poverty.

103. At a macro level also, energy supplies are inextricably linked with incomes and economic output. For instance, the correlation of increasing energy consumption with income (e.g., GDP per capita) has been extensively documented, and it is estimated that a value of 21 GJ (500 kilograms of oil equivalent) of TPES per capita is required to significantly reduce the incidence of poverty in national populations (compared with the 8 to 10 GJ of biomass required to meet basic needs). It has also been found that as national poverty levels decline, the composition of energy supplies increasingly favors liquid fuels (mostly for motorized transportation), electricity (for most household, commercial, and industrial uses), and gas (for cooking and heating), while traditional biomass use falls dramatically and the national energy mix needs to be adjusted accordingly.

104. At the same time, increased dependence on modern forms of energy is also fraught with its own risks for the poor, particularly with respect to the impact of oil price fluctuations. It is estimated that a sustained $10 a barrel increase in oil prices can shave off as much as 1.5% of GDP in the poorest net oil importing countries and exacerbate their poverty levels, in addition to other negative impacts. Similarly, windfall revenues from price hikes in developing energy exporting countries can, in the absence of good governance and monetary policies, accelerate corruption, inflation, and currency devaluation, and—paradoxically—raise poverty levels.

[26] This discussion summarizes the detailed assessment provided inModi, V., S. McDade, D. Lallement, and K. Saghir. 2006. *Energy Services for the Millennium Development Goals*.

Hunger (Target 2)

105. Heat energy is required to cook food, as well as pump water, cultivate crops, and transport agricultural produce. The poor are particularly vulnerable to fuel availability and price changes as they spend a major portion of their incomes on obtaining cooking fuels (as much as 80% of total household expenditure). Unsustainable biomass harvesting results in resource loss and environmental degradation that impacts the poor directly by reducing agricultural productivity, among other factors, primarily affecting rural populations that comprise the bulk of the poor in developing economies.

106. Modern energy supplies and their efficient use, such as with improved cookstoves, can supplement traditional rural energy use in a manner that is more sustainable and reduces the burden of time and labor, especially for women.

Education (Target 3)

107. According to the UNDP, more than 115 million children of primary school age in the world today are out of school. Most of these come from poor households, whose mothers often lack formal education as well. Education, especially for girls, has huge social and economic benefits. Educated women tend to have more economic opportunities, participate more fully in public and social life, and have fewer and healthier children—all factors that are important for breaking the poverty cycle. In addition, children with educated mothers are more than twice as likely to be in school as children of mothers with no formal education. Although significant progress has been made in many parts of the developing world toward universal education, 20% of children still do not attend school in South and West Asia and many Pacific countries. It is also important that once enrolled, children should stay in school. In reality, children from poor communities often drop out because their parents cannot continue to afford to pay their fees, or because they are needed to earn extra income if they are boys, or simply to help with household chores if they are girls. Dropout rates vary from 25% to 40% in parts of Asia, with girls less likely than boys to remain in school.

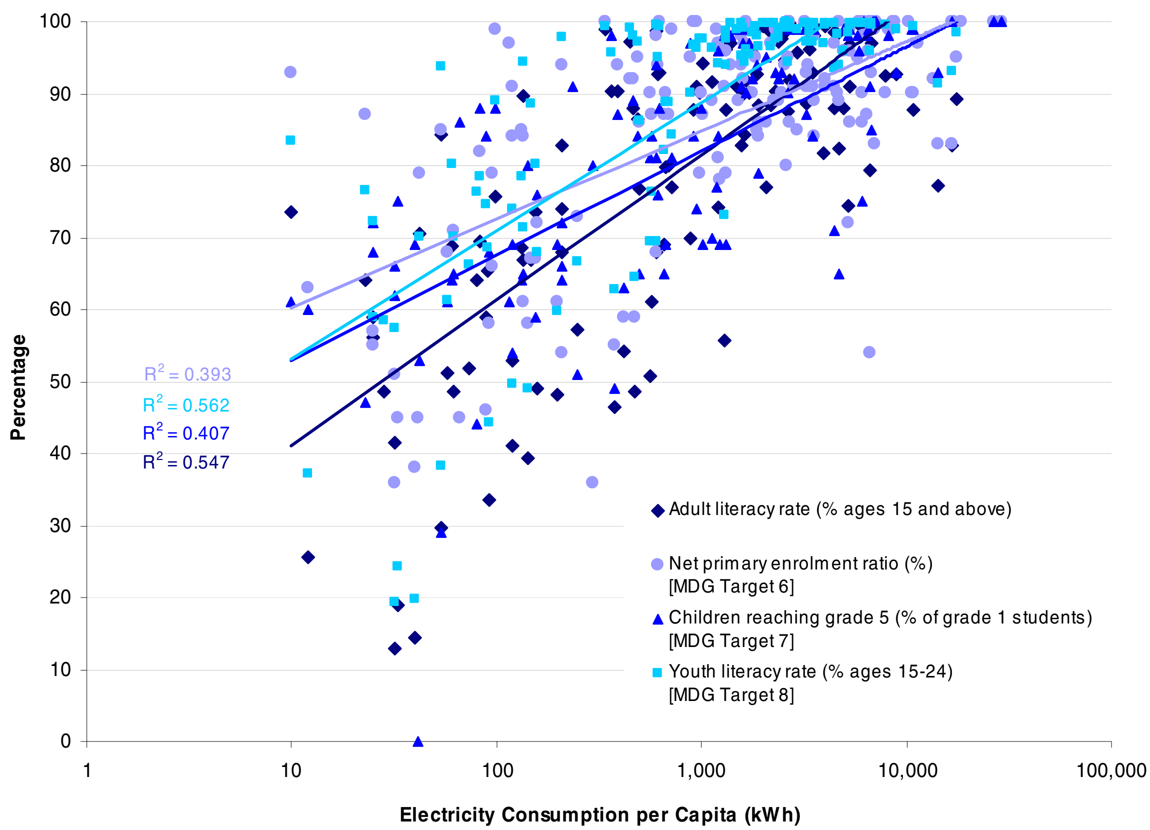
108. Direct evidence exists correlating improved access to modern energy services and educational attainment among the poor. Electrical lighting can extend the hours available for children to study and, particularly for girls, provision of modern household energy can free up more time for attending school and studying at home. Studies in the Philippines have shown that children in electricity-lit homes have higher school performance achievements than children in kerosene-lit homes.

109. Modern energy can also help develop better equipped schools, especially with respect to computers and the Internet, and draw and retain both students and quality teachers in settings that they would otherwise not find attractive or acceptable. In Nicaragua, for example, 72% of children living in a household with electricity attend school, according to one World Bank study, compared with 50% of those living in a house without electricity.

110. **Figure 45** shows the relationship between attainment of the three primary education MDG targets and adult literacy rates versus annual per capita electricity use for all countries of the world for which data are available for 2002–2003. The assumed correlation between these targets and electricity access is generally borne out, although the R^2 values are appreciably less than for HDI in **Figure 32**, indicating that access to electricity is only one of several factors determining improved educational indicators, such as income levels and cultural norms. It is also interesting to note that above an annual per capita consumption of 4,000 kWh (i.e., corresponding to a national HDI of 0.9), the correlation curves lie in the 90%–100% developed country range for each of these parameters. As with the HDI-energy use curve, the logarithmic relationship between per capita electricity use and the attainment of the educational MDGs

indicates that modest energy access improvements can provide disproportionately large benefits among the poorest populations.

Figure 45: Education MDG Targets and Electricity Use by Country, 2002–2003



kWh = kilowatt-hour; MDG = Millennium Development Goal.
Source: UNDP. 2006. *Human Development Report 2005.* New York: UNDP.

Gender Equality (Target 4)

111. The energy-poverty nexus has a distinct gender bias: of the world's poor, 70% are women. Access to and the forms of energy used by a poor community have significantly different impacts on the men and women in it. Existing social and work patterns, particularly in rural communities, place a disproportionate burden of fuel and water collection and their use in the household for cooking on women and girl children, who consequently have to devote long, exhausting hours to this purpose rather than more productive activities, family welfare, or education. However, women's role in decision-making within the household and community is usually very restricted, reducing their say in issues of spending levels and choices, including with respect to energy. This includes the types of fuels used, amounts of energy purchased, the devices and technology chosen, as well as domestic infrastructure characteristics (e.g., stove design, ventilation, etc.). Such decisions are made by the male head of the household, although their burden is borne by the women.

112. The excessive reliance on solid biomass fuels common in rural households has a direct, adverse impact on female and child health, as described below. The incidence and

consequences of such health issues are made worse when combined with the inferior levels of nutrition and medical care available to them in typically patriarchal rural societies.

113. There are also distinct gender attributes to the perceptions and benefits of modern energy among rural populations. For instance, men may view electricity in terms of quality of life and education for their children, while women see it as reducing their workload, improving health, and reducing drudgery. In some cases, it has been observed that the supply of electricity and diesel (for irrigation pumps and tractors, for instance) can greatly reduce manual labor required of men to look after draft animals to till the soil and lift water, while it can have little or no impact on the daily chores that women have to perform. In other cases, modern energy can bring unexpected results, such as the education and empowerment of isolated and confined womenfolk through television, particularly about modern, labor-saving alternatives and lifestyles that they may otherwise remain ignorant about.

114. The ways in which modern energy services can positively impact this gender imbalance and improve the position of women in poor communities is summarized in **Figure 46**. It is apparent from this that modest levels of improved energy supplies can bring with them a multitude of additional benefits for a large proportion of the poor population that suffers the most under the existing energy regime. The scale of the economic payback from such investments and corresponding emancipation of a majority of the developing world's women, enabling them to play a more productive role in society, can only be guessed.

Figure 46: Benefits of Modern Energy Services for Women in Poor Communities

Energy Form	**Benefits**		
	Practical	**Productive**	**Strategic**
Electricity	Pumping water; reducing the need to haul and carry mills for grinding; lighting improves working conditions at home.	Increase possibility of activities during evening hours; provide refrigeration for food production and sale; power for specialized enterprises, such as small businesses.	Make streets safer; allowing participation in other activities (evening classes, community meetings, etc.); open horizons through radio, television, and the Internet.
Improved biomass (supply and conversion technology)	Improved health through better stoves; less time and effort in gathering and carrying firewood; more time for child care.	More time for productive activities; lower cost of process heat for income-generating activities.	Control of natural forests in community forestry management frameworks.
Mechanical	Milling and grinding; transport and portering of water and crops.	Increase variety of enterprises.	Transport; allowing access to commercial, social, and political opportunities.

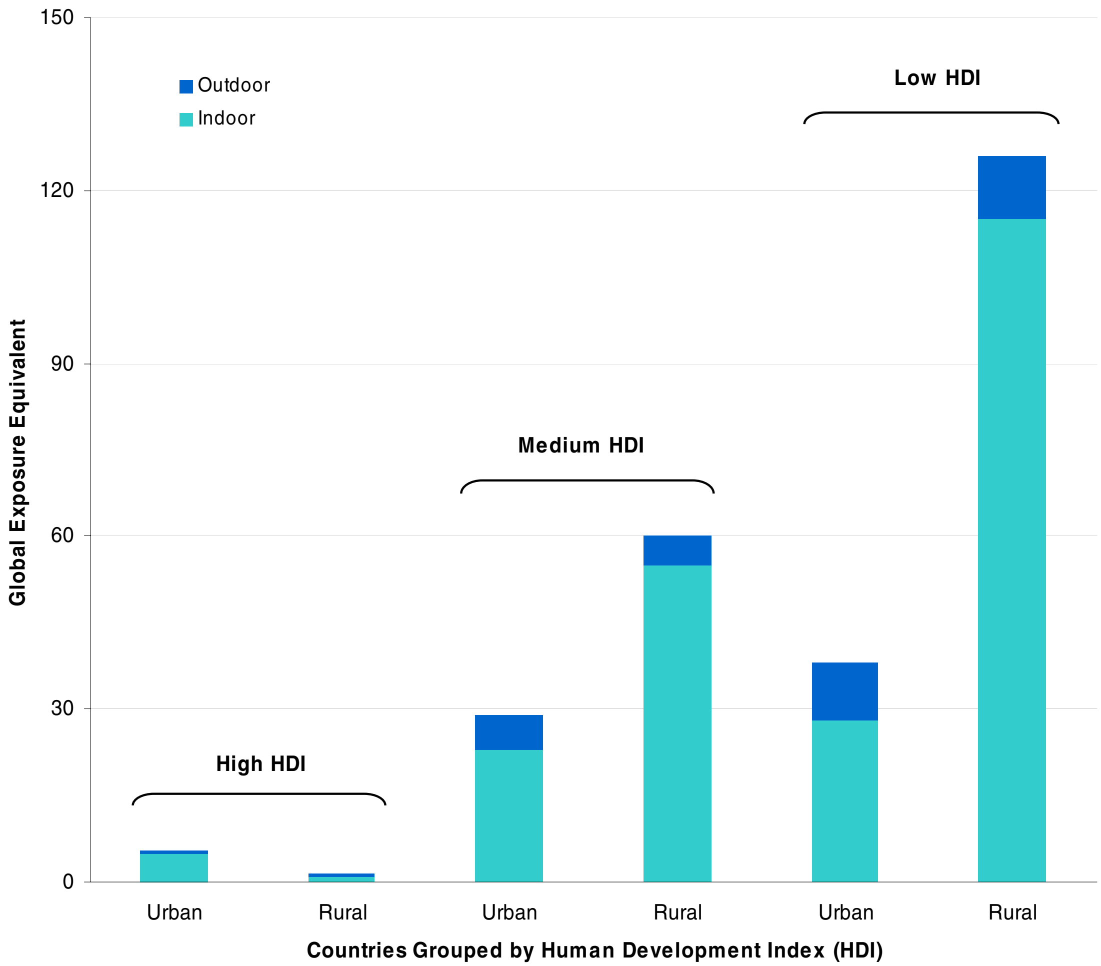
Source: Clancy, J.S.M. Skutsch, and S. Batchelor. The Gender–Energy–Poverty Nexus: Finding the Energy to Address Gender Concerns in Development. Project CNTR998521. London: UK Department for International Development.

Health (Targets 5–8)

115. The form of energy use can directly or indirectly impact human health, while the availability of modern energy services is essential for the provision of modern preventive, diagnostic, and treatment care. In particular, smoke emissions from the burning of solid biomass

in unventilated spaces using traditional cookstoves can lead to increased disease burden and morbidity, especially among poor women and children in developing countries where such traditional fuel use is widespread. Ingestion of particulates, carbon monoxide, and formaldehyde contained in smoke from such traditional fuels increases the risk factors for acute respiratory infections, acute lower respiratory infections, chronic bronchitis, chronic obstructive pulmonary disease, lung cancer, low birth weights, and blindness. According to the World Health Organization, studies from Asia, Africa, and the Americas have shown that indoor air pollution levels in households reliant on biomass fuel or coal are extremely high. For example, typical 24-hour mean concentration levels for particulate matter of 10 micron (μm) diameter or less (PM10) in homes using biomass fuels are around 1,000 micrograms (μg)/m^3, compared with the current limit of 150 μg/m^3 set by the United States Environmental Protection Agency (US EPA). Thus, typical concentrations of indoor air pollutants in poor household relying on such fuels exceed generally accepted guideline limits many times over. This is especially true for rural populations in developing countries that depend mainly on traditional biomass fuels. The rural–urban differential, as well as the difference in exposure to airborne particulates between countries at various levels of economic and human development, is striking, as shown in **Figure 47**.

Figure 47: Global Exposure Equivalents for Particulates in Major Microenvironments



HDI = Human Development Index.
Note: "Global Exposure Equivalent" is defined as the equivalent (particulate) concentration that the entire world's population would have to breathe continuously to equal the population exposure in each microenvironment.
Source: UNDP and WEC. 2000. *Energy and the Challenge of Sustainability.* New York: UNDP and WEC. Data for various years from the late 1980s to early 1990s.

116. Rural women in developing countries spend, on average, from 3 hours to 7 hours a day near the stove fire, and consequently suffer high levels of exposure over their lifetimes. It is not surprising, then, that indoor air pollution is the fourth leading cause of premature deaths in developing countries, of which 60% are female.[27] Women are also exposed to other health-related vulnerabilities during the often arduous task of fuel collection—back and foot injuries, wounds and cuts, sexual harassment, predatory attacks, and exposure to extreme hot or cold weather—that can also significantly impact their medical treatment requirements and costs.

117. Children in poor families are equally at risk, as the large number of daily hours women spend collecting and using solid biomass fuel leaves them with little time to devote exclusively to the needs of their young. Invariably, infants accompany their mothers, and young children assist them, during fuel collection and cooking and are thus subjected to the same health impacts. A World Bank assessment[28] states that approximately 10 million children under the age five died in low-income countries in 1999—2.1 million in India alone. Based on the Indian situation, the report concludes that investments in improving household environmental conditions, including access to piped water, electricity, and separate kitchens with clean cooking fuels and efficient stoves, can substantially reduce child mortality among the developing world's poor (see also **Figure 40**).

118. Modern energy supplies essential for proper health care facilities, management, training, and service delivery include reliable electricity for illumination, medical equipment, refrigeration, sterilization, security, and information and communication technology (ICT) purposes, gas for space and water heating, and liquid fuels for transporting patients, medical staff, and supplies to and from clinics and health centers. Education and awareness about epidemics and hygiene, particularly pandemics such as HIV/AIDS, can be greatly enhanced through modern mass communication media, such as radio and television, which require electricity.

119. The unavailability of clean water and proper sanitation, a major cause for ill health and disease in poor families, is also directly linked with modern energy, which is required to lift subsoil water or to boil it before use. Reduced access also means more time required to fetch supplies from distant sources (usually by women) or lower per capita consumption, both of which are detrimental to health and sanitation levels.

120. Finally, modern energy supplies can also partly offset loss of human labor and productivity due to illness or disease, reducing the susceptibility of the poorest already weakened by first-order health impacts to related secondary or exacerbating threats, such as consequent loss of income and crops.

Environmental Sustainability (Target 9)

121. The production, distribution, and use of energy is the greatest single determinant of environmental decline through associated land degradation, air pollution, acidification of water and soils, and greenhouse gas emissions. In particular, unchecked biomass harvesting can lead to land and ecological degradation, while fossil fuel exploration, production, transformation, distribution, and eventual combustion has unavoidable detrimental local, regional and global consequences. Inexorably linked to climate change, the production and use of all energy forms have a disproportionately high impact on the developing world's poor who remain the most vulnerable to the possible effects of global warming.

[27] Modi, V., S. McDade, D. Lallement, and K. Saghir. 2006. *Energy Services for the Millennium Development Goals*, page 28.

[28] World Bank. 2004. *Global Monitoring Report: Policies and Actions for Achieving the Millennium Development Goals and Related Outcomes.*

122. While deforestation may have many causes other than fuelwood collection that are more important contributors, such as logging, commercial charcoal production, conversion of land to agricultural use, etc., studies show that continued fuelwood harvesting can accelerate such depletion while also diverting biomass away from soil conditioning that can aid vegetative regrowth. Although conditions resulting in deforestation and their underlying determinates may be complex and location-specific, there is little doubt that reducing biomass fuel dependence among the poor, for instance, by increasing use of liquid and gaseous fuels, can help relieve the pressure on such natural resources and improve their sustainability.

123. The impact of energy use on climate change and its consequences is complicated by the fact that fossil fuel use and the resulting GHG emissions on a per capita basis are much lower in the developing world compared with industrialized nations. Apart from implications on GHG capping levels and mitigation responsibilities, this highlights several factors that need to be recognized: (a) that, with a few exceptions (noted below), developing countries' use of fossil fuels has predominantly local economic and environmental consequences, while that of the developed world has been the primary contributor to global GHG concentrations; (b) that the contribution of developing countries to global emissions is steadily increasing, and expected to match or exceed that of the developed countries if present growth trends continue, especially in large Asian countries (e.g., the PRC and India); (c) that the negative impacts of climate change are conversely the greatest on the developing nations, particularly the poorer segments of their populations; and (d) that the increasing populations of developing countries, specially in Asia, will result in significant total emissions even if per capita levels remain low. As developing countries grow, they will transition to increasing per capita use of fossil fuels, while reducing their vulnerability to climate change due to reduced dependence on land-based production; however, their per capita GHG emissions are expected to remain below those of the industrialized countries into the foreseeable future. Thus, from an environmental sustainability point of view, climate change will become an increasingly important issue for developing Asia as both contributor and affectee.

124. The heightened vulnerability of the poorest living off the land in developing countries to the effects of climate change has been discussed earlier in **Section 4**. At the national level too, developing countries with a high reliance on biomass and hydropower energy resources can be adversely affected by changes in precipitation, loss or variability of hydroelectric potential, variations in runoff leading to silting of hydroelectric reservoirs, and impacts of biomass fuel production.

125. Furthermore, many developing countries' present high reliance on renewable energy resources (primarily biomass and hydropower), may allow these countries to achieve many-fold increases in energy consumption with much less associated GHG emissions compared with those in some OECD countries (e.g., the US)—i.e., their national primary energy supply portfolios can remain cleaner even while being made more sustainable (by substituting, for example, non-sustainable biomass use with LPG), resulting in significant deviation from the typical growth path blazed by the present group of industrialized countries. Thus, at a global level, the energy choices and growth of many of the poorest countries are not necessarily the most threatening from an environmental perspective, and this can be further ensured through appropriate interventions directed at creating a more sustainable energy infrastructure for the future. The real sustainability challenge lies in steering the course of countries already approaching the transition to industrialized nation status and those with large populations where, despite relatively low per capita emissions, the total GHGs produced are substantial and rising fast, particularly large Asian countries such as the PRC and India and medium-sized nations such as Indonesia, Pakistan, the Philippines, and Bangladesh.

Water Supply and Sanitation (Target 10)

126. Modern energy supplies facilitate and power improved water supply and sanitation systems, directly improving health, nutrition, and living conditions among the poor who are often deprived of clean water and therefore exposed to heightened risk of water- and vector-borne diseases. Electricity and gas are also required to pump water for household, agricultural, and commercial needs and to boil water for domestic and medical use.

127. At the national level, large hydropower projects provide synergies with energy production and water resource management, while modern energy is also required for the construction and operation of the industrial, commercial, and domestic supply and sanitation infrastructure required to meet the MDG targets for the supply of safe drinking water and improved sanitation to the poor.

128. The UNDP's assessment of the energy needs for the MDGs concludes:[29] "It is clear that energy services have an impact on all of the MDGs and associated targets. Access to energy services facilitates the achievement of these targets. Failure to consider the role of energy in supporting efforts to reach MDGs will undermine the success of the development options pursued, the poverty reduction targets, as well as the cost effectiveness of the resources invested."

129. In charting a future strategy, **Part III** discusses the importance of including energy access and supply as an explicit development goal in its own right, the energy required to meet the existing MDGs, and the ways in which both these objectives can be addressed through appropriate action.

[29] Modi, V., S. McDade, D. Lallement, and K. Saghir. 2006.*Energy Services for the Millennium Development Goals*, page 32.