Energy and Sustainability

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Abstract

Energy is at the heart of most critical economic, environmental and developmental issues facing the world today. Clean, efficient, affordable and reliable energy services are indispensable for global prosperity. Countries in particular need to expand access to reliable and modern energy services if they are to reduce poverty and improve the health of their citizens, while at the same time increasing productivity, enhancing competitiveness and promoting economic growth. Access to clean water and sanitation is constrained without effective pumping capacity. Food security is adversely affected, often with devastating impact on vulnerable populations. The "energy-poor" suffer the health consequences of inefficient combustion of solid fuels in inadequately ventilated buildings, as well as the economic consequences of insufficient power for productive income-generating activities and for other basic services such as health and education.

Keywords: Energy, Sustainability, Development, Indicator, Dimension, Energy-efficiency

Introduction

Since the dawn of the industrial age, the ability to harness and use different forms of energy has transformed living conditions for billions of people, allowing them to enjoy a level of comfort and mobility unprecedented in human history and freeing them to perform ever more productive tasks. For most of the last200 years, steady growth in energy consumption has been closely tied to rising levels of prosperity and economic opportunity in much of the world (TWAS, 2008).

Now, however, humanity finds itself confronting an enormous energy challenge. This challenge has at least two critical dimensions. On the one hand, it has become clear that current patterns of energy use are environmentally unsustainable. Overwhelming reliance on fossil fuels, in particular, threatens to alter the Earth's climate to an extent that could have grave consequences for the integrity of vital human and natural systems. At the same time, access to energy continues to divide the 'haves' from the 'have-nots'. Globally, a large fraction of the world's population more than two billion people, by some estimates still lacks access to one or several types of basic energy services, including electricity, clean cooking fuels and adequate means of transportation.

Energy use by human societies has historically been marked by four broad trends (TWAS, 2008):

- Rising overall consumption as societies industrialize, gain wealth and transition from traditional sources of energy (mostly biomass-based fuels such as wood, dung and charcoal to commercial forms of energy (mostly fossil fuels).
- Steady improvements in both the power and efficiency of energy-producing and energy-using technologies.
- De-carbonization and diversification of fuels used, especially for the production of electricity, throughout most of the 20th century.
- Reduction in conventional pollutants associated with energy use.

SUSTAINABLE DEVELOPMENT

In simple terms, sustainability is living forever from nature without hurting it. Long-term, our chosen energy options must be sustainable, because energy is essential for services such as warmth, mobility and mechanical power, lighting and electronics. It is also essential for obtaining materials, by mining and refining, synthesis, and recycling.

Sustainability has two requirements (Bossel, 2003):

- The harvesting of energy and materials from nature.
- The return to nature of products and wastes arising from the use of energy and materials. These can arise anywhere in the chain between the source and the sink.

'Sustainable development' has been defined best by the Brundtland Commission as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (UN, 2005). Adequate and affordable energy supplies have been key to economic development and the transition from subsistence agricultural economies to modern industrial and service oriented societies. Energy is central to improved social and economic well-being, and is indispensable to most industrial and commercial wealth generation.

Achieving sustainable economic development on a global scale will require the judicious use of resources, technology, appropriate economic incentives and strategic policy planning at the local and national levels. It will also require regular monitoring of the impacts of selected policies and strategies to see if they are furthering sustainable development or if they should be adjusted.

DIMENSIONS OF SUSTAINABLE DEVELOPMENT

Sustainable development is essentially about improving quality of life in a way that can be sustained, economically and environmentally, over the long term supported by the institutional structure of the country. For this reason, sustainable development addresses four major dimensions: social, economic, environmental and institutional (UN, 2005).

Social Dimension

Availability of energy has a direct impact on poverty, employment opportunities, education, demographic transition, indoor pollution and health, and has gender- and age-related implications. In rich countries, energy for lighting, heating and cooking is available at the flip of a switch. The use of energy should not damage human health, but rather should improve it by improving living conditions. Yet the production of energy has the potential to cause injury or disease through pollution generation or accidents. A social goal is to reduce or eliminate these negative impacts. The Health indicators have the sub-theme of Safety, which covers accident fatalities caused by the extraction, conversion, transmission/distribution and use of energy.

Economic Dimension

Modern economies depend on a reliable and adequate energy supply, and countries need to secure this as a prerequisite for industrialization. All sectors of the economy residential, commercial, transport, service and agriculturedemand modern energy services. The economic indicators have two themes: Use and Production Patterns, and Security. The first has the subthemes of Overall Use, Overall Productivity, Supply Efficiency, Production, End Use, Diversification (Fuel Mix) and Prices. The second has the subthemes of Imports and Strategic Fuel Stocks.

Environmental Dimension

The production, distribution and use of energy create pressures on the environment in the household, workplace and city, and at the national, regional and global levels. The environmental impacts can depend greatly on how energy is produced and used, the fuel mix, the structure of the energy systems and related energy regulatory actions and pricing structures. The Environmental indicators are divided into three themes: Atmosphere, Water and Land. The sub-themes on the Atmosphere are Climate Change and Air Quality. Priority issues include acidification, the formation of tropospheric ozone and emissions of other pollutants affecting urban air quality. Greenhouse gas (GHG) emissions are central to the debate on whether humankind is changing the climate for the worse.

SUSTAINABLE ENERGY

Sustainable energy is the provision of energy that meets the needs of the present without compromising the ability of future generations to meet their needs.

Sustainable energy sources include all renewable energy sources, such as hydroelectricity, solar energy, wind energy, wave power, geothermal energy, and tidal power. It usually also includes technologies designed to improve energy efficiency.

Energy efficiency and renewable energy are said to be the *twin pillars* of sustainable energy. Some ways in which *sustainable energy* has been defined are (REFP, 2004):

"Effectively, the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their own needs. ...Sustainable Energy has two key components: renewable energy and energy efficiency.

Sustainable energy can produce some pollution of the environment, as long as it is not sufficient to prohibit heavy use of the source for an indefinite amount of time. Sustainable energy is also distinct from Low-carbon energy, which is sustainable only in the sense that it does not add to the CO_2 in the atmosphere.

Much of the current energy supply and use, based, as it is, on limited resources of fossil fuels, is deemed to be environmentally unsustainable. There is no energy production or conversion technology without risk or without waste. Somewhere along all energy chains from resource extraction to the provision of energy services pollutants are produced, emitted or disposed of, often with severe health and environmental impacts. Even if a technology does not emit harmful substances at the point of use, emissions and wastes may be associated with its manufacture or other parts of its life cycle.

When choosing energy fuels and associated technologies for the production, delivery and use of energy services, it is essential to take into account economic, social and environmental consequences. Policymakers need methods for measuring and assessing the current and future effects of energy use on human health, human society, air, soil and water. They need to determine whether current energy use is sustainable and, if not, how to change it so that it is. This is the purpose of the energy indicators presented in this report, which address important issues within three of the major dimensions of sustainable development: economic, social and environmental.

For energy supply, only renewable sources can satisfy the sustainability criteria. However, even some renewable are not always harvested sustainably. Ethanol from corn is not sustainable as the total fossil energy input from plowing the fields to distilling the mash may exceed that of the end-product, and large quantities of water are required. Silt deposits in water reservoirs may gradually reduce the hydroelectric power production.

The sustainability criteria are best satisfied by solar, wind, wave and most hydropower options. This renewable energy is available "above ground" in our biosphere. Thus installations for harvesting renewable from sun, wind, and waves are all visible. Land for energy production is occupied, but not consumed by installations. Although there may become visual impacts, most "above-ground" renewable energy facilities satisfy the sustainability criteria.

RENEWABLE ENERGY TECHNOLOGIES

Renewable energy technologies are essential contributors to sustainable energy as they generally contribute to world energy security, reducing dependence on fossil fuel resources and providing opportunities for mitigating greenhouse gases. The International Energy Agency states that (Steffen, 2009):

Conceptually, one can define three generations of renewable technologies, reaching back more than 100 years. First-generation technologies emerged from the industrial revolution at the end of the 19th century and include hydropower, biomass combustion, and geothermal power and heat. Some of these technologies are still in widespread use. Second-generation technologies include solar heating and cooling, wind power, modern forms of bioenergy, and solar photovoltaic. These are now entering markets as a result of research, development and demonstration (RD&D) investments since the1980s. Many of the technologies reflect significant advancements in materials. Third-generation technologies are still under development and include advanced biomass gasification, bio refinery technologies, concentrating solar thermal power, hot dry rock geothermal energy, and ocean energy. Advances in nanotechnology may also play a major role.

ENERGY EFFICIENCY

Moving towards energy sustainability will require changes not only in the way energy is supplied, but in the way it is used, and reducing the amount of energy required to deliver various goods or services is essential. Opportunities for improvement on the demand side of the energy equation are as rich and diverse as those on the supply side, and often offer significant economic benefits. (IAC, 2007)

Energy efficiency is the key to driving incremental reductions in energy intensity. It is one of the few "noregret" policies that can offer a solution across challenges as diverse as climate change, energy security, industrial competitiveness, human welfare and economic development. While it offers no net downside to energy-consuming nations, the benefits have proved difficult to capture.

There is a strong correlation between energy consumption and economic growth, and the term "energy intensity "provides a way of understanding the evolution of this relationship ((Douglas, 2008). Energy intensity can be reduced in two ways: First, higher energy efficiency can reduce the energy consumed to produce the same level of energy services. Second, the economic structure of individual markets can shift from high energy intensive activities such as manufacturing to low energy intensive activities and sectors such as services, while keeping same or higher levels of total GDP.

There are substantial energy efficiency improvement opportunities on both the supply side and the demand side. On the supply side, the power sector in the developing world in particular has substantial potential to improve the efficiency of power generation and to reduce transmission and distribution losses, thereby reducing the amount of primary energy (e.g., coal, gas, oil) consumed for the same output.

The demand side includes end-use efficiency opportunities in industry, buildings and transport. The type of response will differ by sector. For buildings, much will depend on the widespread uptake of energy-efficient electric equipment and efficient lighting. In the transport sector, a mix of energy-efficient vehicles including all-electric and hybrid electric vehicles, integrated traffic planning and modern public transportation systems can create significant gains. In industry, special attention should be focused on small and medium-size enterprises and on systems approaches that go beyond the process or technology level.

In recent decades, some developing countries have also been increasing their GDP significantly faster than their energy consumption, leading to a reduction in their energy intensity. In absolute terms, however, developing countries' average energy intensity level is three times that of the developed countries.

Governments have an important role to play in promoting energy efficiency and conservation. Efficiency standards for appliances, equipment and automobiles. Efficiency standards or codes for buildings, especially commercial buildings, are extremely important given the long lifespan of most structures. To be effective, however, countries will need to educate architects and builders and develop the capacity to monitor and enforce compliance.

Energy-efficiency or 'demand-side management' programmers can provide a number of benefits in developing countries, including reducing costs to customers, easing electricity supply problems, enhancing system reliability and moderating rapid demand growth.

Technologies

The different energy supply technologies that will likely play a role in a carbon constrained future have been extensively reviewed elsewhere. The usual list includes renewable energy technologies, nuclear technology and advanced fossil-fuel systems with carbon capture and sequestration (IAC, 2007).

A number of renewable energy technologies have improved to the point where they can now provide electricity at lower cost than other supply options wherever grid extension is prohibitively expensive or uneconomic. There are six broad categories of renewable energy technologies biomass, wind, solar, hydro, geothermal and marine. They can be tapped using a variety of conversion technologies or processes to produce a range of energy services, including electricity, heat (or cooling), fuels, mechanical power and illumination.

The competitiveness of different renewable technologies in different settings depends on their cost and performance, as well as on the local cost and availability of fossil-based energy. Both factors still vary widely and depend strongly on local conditions confer (RETF, 2001).

Countries must take the lead in charting a new energy course for themselves. These policy actions include:

- Promote energy efficiency and adopt minimum efficiency standards for buildings, appliances and equipment, and vehicles.
- Reform and re-direct energy subsidies.
- Identify the most promising indigenous renewable energy resources and implement policies to promote their sustainable development.
- Seek developed-country support for the effective transfer of advanced energy technologies, while building the indigenous human and institutional capacity needed to support sustainable energy technologies.
- Accelerate the dissemination of clean, efficient, affordable cook stoves.

Subsidy reform

Although energy subsidies have been declining in many parts of the world over the last decade, subsidies for fossil fuels still amount to several tens of billions of U.S. dollars in developing countries. Cumulatively, these subsidies total less than overall taxes imposed on such fossil fuels as petrol (RETF, 2001).

Reforming and redirecting energy subsidies if necessary over time rather than all at once may thus be a more realistic strategy for developing countries than attempting to abolish subsidies all at once. Alternatively, the public resources conserved by reducing subsidies could be directed toward other societal needs. Where there is concern that poor households will not be able to access basic energy services if they have to pay the full market price, it might be feasible to provide subsidies only up to a certain level of consumption. This is more likely to be practicable in the case of electricity.

In the longer-run, of course, energy prices for fossil fuels should not only be subsidized, but also increased to reflect environmental and public health externalities that are currently unrecognized by the marketplace. In principle, monetizing positive and negative externalities and making sure they are included in energy prices is an elegant way to address many issues of sustainability. Absent this step, the market will tend to over-allocate resources where there are negative externalities (such as pollution) and under-allocate resources where there are positive externalities (such as improved energy security).

The difficulties associated with internalizing externalities are essentially parallel to those associated with removing subsidies, with the added complication that it is often difficult to place a precise monetary value on certain impacts.

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The indicators are not merely data; rather, they extend beyond basic statistics to provide a deeper understanding of the main issues and to highlight important relations that are not evident using basic statistics. They are essential tools for communicating energy issues related to sustainable development to policymakers and to the public, and for promoting institutional dialogue. Each set of indicators expresses aspects or consequences of the production and use of energy (UN, 2005).

The indicators presented here constitute a core set of Energy Indicators for Sustainable Development (EISD) with corresponding methodologies and guidelines useful to policymakers, energy analysts and statisticians. Some indicators focus on the delivery of essential energy services for reducing poverty and improving living conditions, while other indicators focus on environmental effects. It is important to take not only the economic but also these social and environmental issues into account when deciding on policies.

Some of these indicators are unequivocal measures of progress; they clearly distinguish between desirable and undesirable trends. Most of the social and environmental indicators fall into this category, including such indicators as SOC4 (accident fatalities), ENV3 (air pollutant emissions from energy systems) and ENV6 (rate of deforestation attributed to energy use). However, some of these indicators also must be taken in context; for example, depending on the development choices made, there may be a temporary rise in undesirable effects until a higher level of development is achieved, representing a larger benefit that could outweigh the interim disadvantages.

Other indicators are not designed to distinguish between 'good' and 'bad' but rather describe and give an indication of an aspect of energy use. Most of the economic indicators fall into this category. They include ECO1 (energy use per capita) andECO3 (efficiency of energy conversion and distribution). Energy use per capita might be low in a given country because that country is very poor or because there is high energy efficiency and the economy is based on services rather than on heavy industry.

The indicators need to be read in the context of each country's economy and energy resources. An economy that is dominated by primary extraction and processing will have relatively high energy use per unit of gross domestic product (GDP) no matter how efficient it is. This does not mean that the country should abandon development of its resource base.

CONCLUSION

For the past 10 to 15 years, the energy sectors in most countries have been in turmoil. Many countries have been attempting to restructure their energy sectors but are finding it difficult to implement reforms for a host of reasons, including the multiplicity of actors involved, changing perceptions of the relative roles of the market and governments, and the baggage of accumulated policies of the past few decades any of which may have made sense when they were proposed but now impose unsustainable burdens.

Meanwhile, a sharp run up in world energy prices over the last two years and growing supply concerns related to conventional petroleum (and, in some parts of the world, natural gas), combined with projections of continued strong demand growth at the global level and greater awareness of the threats posedby climate change, have brought a heightened sense of urgency to national and international energy policy debates.

Surveying the current landscape, ample justifications could be found for a profoundly pessimistic view or an equally optimistic one. Which outlook proves more accurate will depend to a large extent on how quickly developed and developing countries not only recognize, but also begin to act upon, their shared stake in achieving positive outcomes that can be managed only by working together.

Achieving energy efficiency improvements on the scale needed will require an integrated approach, with multilateral organizations, governments, utilities, municipalities, industry and the public sector working together and in parallel. Implementing one or two of the success factors is insufficient: a broad, coordinated approach addressing multiple barriers simultaneously is needed to achieve the "critical mass" needed to help convert the enormous untapped energy efficiency potential into real investments across various sectors.

Sustainable energy policies are more likely to succeed if they also contribute toward other societal and economic development objectives. Governments should look across policies to maximize positive synergies where they exist and avoid creating cost-cutting incentives. Too often, governments in responding to different pressure groups at different times adopt conflicting policies that at least partially undermine each other.

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