Electric Power, Emissions and Economic Development

*by Peter Pearson**

Energy use in the developing world has been growing rapidly over recent decades, both absolutely and relative to the growth in industrialized countries albeit from a very low base. In the next century, developing country commercial energy consumption in general, and electricity consumption in particular, is expected to continue to rise with striking rapidity because of population growth, income growth and substitution of modern commercial fuels for traditional biomass fuels. Because the power sector is one of the fastest-growing energy sectors, it raises significant domestic environmental issues, while the sector's role in global warming scenarios has made it a key feature of international environmental policy. This paper focuses on the relationships between economic development, electric power and polluting emissions.

Historically, developing country electricity consumption showed a 1971-90 growth rate of over 8 percent per year, more than twice as fast as that of the corresponding OECD rate of 3.5 percent per year. A range of scenarios for the 21st century has suggested that although electricity demand growth could continue its recent deceleration in both industrialized countries and developing countries, the developing country rate is likely to fall much more slowly.[1] Consequently, the developing country share in world electricity consumption – and global $C0_2$ emissions – is set to rise and to dominate the industrialized country share through the next century. Over the nearer term, a 1990 study of electric utility expansion plans in seventy developing countries indicated that electricity demand was expected to grow at an average rate of 6.6 percent per year in the 1989-99 period, with total capacity additions of more than 380 GW, raising installed generating capacity, by more than 80 percent.[2] Asia accounted for more than 60 percent of these requirements, Africa for less than 2 percent. The US$745 billion (1989 dollars) of capital expenditure plans were dominated by coal thermal (44 percent), hydro (36 percent) and gas thermal (10 percent). In terms of electricity supply, coal was planned to provide almost one half, while hydro would provide a little less than one third. Coal use would nearly double in volume (bringing significant increases in both domestic and global pollution). And, although funding difficulties experienced by electricity utilities in many developing countries mean that plans are not always fully realized, developing country electricity supplies and their associated environmental impacts are still likely to grow with striking rapidity over the next several decades.

The Sources of Present and Future Electricity Demand

Electricity demand grows with population and with the changing nature, location, level and composition of economic and social activity. Mechanization, industrialization and urbanization are, of course, key factors. So also are transitions to electricity, both from the direct use of fossil fuels and from dependence on biomass fuels (the latter, of course, present their own patterns of environmental impact – on health, through indoor air pollution, and in situations of unsustainable use, on various forms of natural resource degradation).

For those who have access to and can afford electricity and electrical appliances, there are major impacts on the quality of life. However, despite the fact that over the past twenty or so years installed capacity and per capita generation in most of the large developing countries grew more than twice as fast as real GDP, while power connections grew at about two and half times the population growth rate, still only a relatively small proportion of developing country populations are connected to electricity supplies.[3] Moreover, per capita consumption is a fraction of industrialized country levels (average per capita electricity generation in developing countries is 660 kwh, compared with 10,500 kwh in the USA and about 6,000 kwh in OECD, Japan and Europe[4]). It is clear that there is massive latent demand for electricity in developing countries, with all that this implies for economic and social development and for the growth of domestic and international environmental impacts.

Local, Regional and Global Environmental Impacts

Given the expected growth in electricity generation, it is clear that in the absence of major changes in pricing, management, fuel choice and technology, the environmental impacts associated with electricity will grow very rapidly indeed. A number of scenarios for 1990-2030, relating to the expansion of electricity supply in developing countries were prepared by Anderson and Cavendish for the 1992 *World Development Report*.[5] The 'unchanged practices' scenario, in which pollution abatement technologies are not widely used, suggests that the emissions index of three regional and local pollutants (particulate matter, $S0_2$ and NOx) rises exponentially at about 6 percent per year, with the result that emissions increase more than fourfold in the twenty years between 1990 and 2010 and tenfold over the forty years between 1990 and 2030. Other types of environmental impact are also likely to grow commensurably.[6]

For global pollution, given the projected role of fossil fuels, especially coal, in future electricity generation scenarios, and given the rapid growth in the transport sector, it is no surprise to find projections of rapid increases in future developing country $C0_2$ emissions. Numerous scenarios have shown the developing countries' share in global emissions rising from less than 30 percent in 1990 to well over 50 percent by the second half of the 21st century, with the growth in fossil fuel generated electricity being a significant part of this.[7]

Electricity Services and Environmental Quality?

The question then arises whether developing nations can simultaneously pursue *both* the increased electricity services they want and need and also achieve tolerable levels of emissions and environmental quality. One answer is to say 'yes', where there exist exploitable 'no regrets' *energy efficiency* measures, and especially where there exist exploitable 'win-win' *economic efficiency* measures, such as the

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[1] See footnotes at end of text.

pursuit of efficiency in electricity pricing and in the structure, management and regulation of electric utilities. This suggests a degree of complementarity between electricity services and environmental quality. However, there is a need for caution, since greater technical energy-efficiency may even lead to increased electricity consumption and pollution – in many situations, people may simply demand a wider range of cheaper energy services, as the history of the industrialized countries has shown.

Anderson and others have argued, however, that if energy efficiency is pursued according to the principles of economic efficiency, pollution emissions from electricity in developing countries could fall by one-third (possibly more) relative to trend levels, and economic growth could also rise, 'liberating' resources that could be allocated to other urgent priorities, such as water supply, health or education. The potential for improved efficiency in the developing country power sector seems considerable. The World Bank's 1993 power sector review paper said that over the period 1979-88, average real power tariffs in developing countries declined from 5.2 cents to 3.8 cents/kwh, quality of service deteriorated, technical and nontechnical losses and fuel consumption remained high, and poor maintenance of plants persisted. Moreover, the *World Development Report 1992* asserted that: "Prices, on average, are barely more than one-third of supply costs and are half those in industrial countries. ...developing countries use about 20 percent more electricity than they would if consumers paid the true marginal cost of supply. Underpricing electricity also discourages investment in now, cleaner technologies."

It seems reasonable, therefore, to argue that in many developing country power sectors there is significant potential for efficiency reforms which would also yield sizable environmental benefits. However, this needs to be tempered by the acknowledgment that these hypothetical efficiency gains may not be so easy to achieve in practice, given the complex, multi-faceted and multi-obligated nature of public ownership and decision-making in many parts of the developing world. For example, one of the most obvious outcomes of the U.K.'s recent energy privatization programs has been the striking reductions in the workforce in the power sector – employment in the two main generators, National Power and Powergen, has tumbled by more than half since 1990. The short to medium term employment and other implications of recommended power sector reforms in developing countries will pose a serious policy problem for many governments.

Are Economic and Energy Efficiency Sufficient for Long Term Environmental Quality?

The question arises whether even the aggressive pursuit of economic and energy efficiency in the power sectors of developing countries would be sufficient on its own to restrain the growth of environmental impacts. Anderson has argued convincingly that the effects of efficiency on energy use and pollution will differ significantly between the industrialized countries and the developing countries – and in the Anderson and Cavendish 2030 scenarios for particulate matter, SO_2 and NOx, it is the additional substitution towards low-polluting practices and technologies and fuels (induced by targeted environmental policies and 'appropriate incentives') that has the decisive impact on pollution abatement. For a number of the domestic air pollutants, such as particulates, abatement or low-polluting technologies are available and add a relatively small percentage to total costs. In other cases, such as flue-gas desulphurization, or for some alternative fuels, costs are at present somewhat higher.

Thus, pollution abatement is possible but efficiency alone is not enough; high levels of control would require positive decisions to devote – and, significantly, divert – scarce resources. Therefore, simply in order to address the *domestic* environmental impacts of the power sector over the longer term, developing countries will be faced with a need to decide how important environmental quality is relative to other policy objectives, and what resources they are willing and able to deploy to achieve it, in the light of their estimates of the costs and benefits of doing so. It has become fashionable to suggest that the 'Environmental Kuznets Curve', with its inverse U-shaped relation between some environmental quality indicators and per capita GDP, implies that all serious environmental problems will automatically be addressed as economic development proceeds. This dubious proposition is based on an empirical construct that requires deeper and more searching examinations than it has yet received.[8]

The Threat of Global Warming?

For global environmental issues, such as those raised by CO_2, at present poor nations have found it inappropriate to prioritize long-term emissions abatement measures over output and consumption. Modelling exercises have tended to confirm that developing countries with significant fossil fuel resources, such as China and India, with their big coal reserves, could face high levels of loss from CO_2 abatement policies. This is because adjustments to carbon constraints tend to require expensive imports of lower-carbon or noncarbon fuels and technologies, and in any case, raising exports to pay for them tends to augment fuel demand and emissions. However, without a switch away from fossil fuels in general and coal in particular, there seems little prospect of restraining significantly the growth of developing country and hence world CO_2 emissions.

The development needs of many developing country governments make it difficult for them to accept a trade-off of reductions in uncertain, long-term global environmental damage against their plans for short to medium-term economic growth and development. Consequently (and, of course, for strategic bargaining reasons), they tend to argue for compensation and technology transfer to persuade them to adopt the targets of industrialized countries – a position that was reflected in the FCCC at Rio and in the 1995 Conference of Parties in Berlin. Both Rio and Berlin showed that serious questions remain over what greenhouse gas emissions targets should be, who should meet them, and whether accommodations can be reached on targets, finance and technology transfer.

A New Role for Renewables?

It has been argued that, without the further adoption of low-polluting fuels and technologies, economic and energy efficiency will not be sufficient to restrain developing country emissions of domestically damaging air pollutants. Moreover, if it were thought desirable to go for major carbon-

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abating strategies, a switch towards a lower CO_2-emitting fuel, like gas, even were it feasible, would not be sufficient to achieve substantial abatement targets. For various reasons, and notwithstanding its adoption in some of the more rapidly growing Asian economies, a large-scale switch to nuclear electricity in the developing world does not seem a plausible solution. In the absence of successful alternative carbon-removing technologies, and in the event that an apparently significant carbon constraint emerges as an international political reality, the key question will then be whether renewable technologies, particularly photovoltaics, solar thermal and biomass, can develop as successful non-net-carbon-emitting backstop technologies.[9] Anderson has argued that for electricity generation the backstop renewable technologies may even eventually become competitive with fossil fuels, at least in the high insolation areas of the world.

As well as their current limitations, primarily of cost competitiveness with fossil fuels in many existing situations, renewables also have some potential advantages. There are some attractions to smaller-scale local systems, particularly when the necessity and desirability of large single utilities providing power is being increasingly questioned, and when, as CCGT has shown, scale economies need no longer dominate and mean that only big can be beautiful. Moreover, in many developing countries the terrain and population densities are such that the expansion of grid systems to satisfy small loads is very expensive. In Kenya, for example, for low loads, such as lighting, radios and televisions, small-scale photovoltaics have been shown to be commercially competitive with rural electrification via a centralized grid. This has happened even in the presence of high import duties (amounting to more than 30 percent of the final price paid) and in the absence of credit facilities: around 20,000 households have bought solar energy, compared with the 17,000 connected to the official rural electrification program.[10] Local environmental issues are another matter. Exchanging one fuel and technology for another does not abolish, but changes, the pattern of environmental impacts. There are clearly circumstances in which, for example, renewables would not cause the same types of local environmental and social disruption as those associated with some large-scale hydroelectric schemes. On the other hand, there could be significant ecological and other impacts associated with any new, large-scale biomass growing programs.

An important question is whether renewable technologies can develop at the same rates as those which the now-commercial technologies of thermal generation achieved, and how many resources and how long it might take to get to competitive cost levels. Proponents of renewables point to the significant reductions in the costs of photovoltaic and other technologies and compare them with the experience of now-mature fossil-fuel technologies. Anderson quotes long-term expectations of the costs of large-scale use of renewables in electricity generation ranging from 4-6 US cents/kwh (at 1990 prices), while acknowledging present costs ranging from 9-50 cents/kwh. He also stresses the contributions that might be made by current investment to reducing the costs of future investments through combinations of induced innovations and 'learning by doing,' citing as examples the experience of the electricity industry over much of this century, when costs fell twenty-fold over the sixty years from 1900, and the thermal efficiencies of power plants rose ten-fold. It is argued that while the contribution of current investment to reductions in the unit costs of later investment may not be large, the overall benefits of investing in and developing a technology can be substantial if the prospective use of the technology is big - it is the product of the two effects that matters. Any such positive externalities of falling costs, imply benefits that would not be fully captured by current private investors, but which should be included in a social project appraisal (although it would also be essential to take into account the possibility of falling costs in conventional non-renewable generating technologies). The existence of such externalities would also lend support to an argument for governments to devote resources to enhance the development of appropriate renewable technologies.

If it were decided to do this, the problem of the inability of governments to 'pick winners' suggests that a diversified portfolio, including non-renewables, would spread the risks. In the past, for example, governments have tended to respond to energy security problems by selecting and supporting effectively single-technology strategies (such as the U.K.'s past focus on support for R&D and investment in nuclear electricity).

Thus, a question that needs investigating in more depth is whether, given the possibility of a need to take strenuous action to restrain carbon emissions and also given the size of potential markets for small and large-scale electricity generation technologies in developing countries in the 21st century, there might be a coming-together of diverse interests - industrialized country and developing country governments and international and local suppliers of new technologies - which could lead to the development of less locally and globally environmentally-damaging electricity services in developing countries.

Cooperation, partly on the basis of anticipated gains from trade, seems a lot more attractive than conflict. The possibility of falling costs might well spur on the activities of commercial organizations attracted by the prospect of an international market that could be very big in the presence of significant carbon constraints and, even in their absence, could form a sizable market for cost-effective electricity in situations where standard technologies, fuels or distribution systems tend to be problematic. More than this, in his observation about lighting in Africa, Robert van der Plas reminds us why electricity matters: "The level of services many rural households 'enjoy' now is only barely distinguishable from that of medieval Europe."[10]

Footnotes

[1] For example: Eden, R. (1993), 'World Energy to 2050: Outline Scenarios for Energy and Electricity, *Energy Policy*, 21(3); Energy Information Administration (1995), *International Energy Outlook 1993*, U.S. Department of Energy, Washington, DC. See also his paper on 'Electricity and Environmental Policy' in the Conference Proceedings.

[2] Moore, E. A. and Smith, G. (1990), Capital Expenditures for Electric Power in the Developing Countries in the 1990s, World Bank, Washington, DC.

[3] World Bank (1993), *The World Bank's Role in the Electric Power Sector*, World Bank, Washington, DC.

[4] Energy Information Administration (1995), op. cit.,

note 2.

[5] Anderson, D. and Cavendish, W. (1992), 'Efficiency and Substitution in Pollution Abatement: Three Case Studies,' *World Bank Discussion Paper No. 186,* World Bank, Washington, D.C., World Bank (1992), *World Development Report 1992,* CUP, Oxford.

[6] See, for example, Brandon, C. & Ramankutty, R. (1993*), Toward an Environmental Strategy for Asia,* World Bank Discussion Paper 224, Washington, DC.

[7] See also Pearson, P.J.G. (1993), 'The Environmental Impacts of Electricity Generation in the Third World,' IEE *Proceedings-,4, Science, Measurement & Technology, 140* (1), 100-108.

[8] Pearson, P.J.G. (1994b), 'Energy, Externalities and Environmental Quality: Will Development Cure the Ills it Creates?', *Energy Studies Review,* 6(3).

[9] For detailed arguments, and estimates of the role of renewables as non-net-carbon-emitting backstop technologies, in the context of proposed projects for the Global Environmental Facility, see Anderson, D. (1994), 'Cost-Effectiveness in Addressing the "CO_2 Problem," *Annual Review of Energy and Environment 1994,* 19.

[10] van der Plas, R. (1994), 'Solar Energy Answer to Rural Power in Africa', FPD Note 6, World Bank, Washington, DC.

Waverman Appointed to Ontario Advisory Committee

Leonard Waverman, editor of *The Energy Journal,* has been appointed to the seven member Advisory Committee on Competition in Ontario's Electricity System.

The committee is to evaluate options for increasing competition and competitiveness in the Ontario, Canada electric utilities system. Specifically, the committee is to examine options in (1) structural changes to the electric utility industry, (2) regulatory reform to ensure a healthy competitive environment and (3) introduction of private equity in the electric utility sector.

The committee, chaired by former Privy Council President Donald S. Macdonald, is expected to report to the Minister of Environment and Energy in the spring of 1996.

Problems of Efficient Energy Supply and Consumption and Development of a New Energy Policy in East European Countries

Notes from Belarus Workshop of 4-6 October

This East European workshop was held at the German-Byelorussian Educational Centre with support from the Belarus Ministry of Fuel and Power Engineering, the Academy of Sciences of Belarus, the European Foundation for Cooperation in Energy Economics, the IAEE and the IAEE Byelorussian Affiliate.

Over 200 representatives of energy companies, research institutions, universities and other organizations took part in the workshop with individuals coming from Russia, Ukraine, Moldova, Kazakhstan, Lithuania, Latvia, Estonia, Poland, Germany, Sweden, Netherlands, Great Britain, Denmark and Finland.

Following the disintegration of the USSR, Belarus faced a very difficult energy situation. Lacking energy resources of its own, Belarus was forced to import them from Russia at essentially world prices. This high cost of energy virtually strangled the republic's economy, as the annual cost of its energy imports was very close to the Belarus' national income. As a result, the Belarus debt from energy purchases is about US $1 billion with little prospect of it being paid off.

At the same time, the power consumption per unit of production is roughly two to three times that of Western European countries. With this situation, Belarus is clearly faced with the need to develop a new energy policy which is oriented toward energy saving technologies for both production and consumption. Further, Belarus is typical of other Eastern European countries. Given this background, the focus of the workshop was first on clearly defining the problem and then hearing possible solutions from experts, primarily from the west.

Speakers included the Vice Premier of the Belarus Cabinet of Ministers, V. Kokorev; the Belarus Minister for Fuel and Power Engineering, V. Gerasimov, as well as a number of deputy ministers or their representatives. Speakers from the west include IAEE past president, Ulf Hansen of Rostock University, Kurt Lekas of Stockholm Energy, M. Weisheimer of the Institute fur Wirtschaftsforschung Halle and F. van Oostvoorn of the Netherlands Energy Research

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