Providing Access to Electricity for the Unserved: A Free-Market Solution

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The traditional problem often called "electricity development" is to improve and expand services from an established monopolistic electricity supplier. The lack of an effective dominant utility, however, is a defining condition for the 1.4 billion people without access for electricity, the so-called unserved. Therefore, the issues that arise are different from those of traditional utility service as a mandated monopoly. This article shows how free markets can help resolve the problem of serving the unserved.

The free-market approach and empirical examples in this article may appear counterintuitive compared to the traditional solution to the access problem when a preexisting legally franchised monopoly supplier exists. In much of the developing world such franchised monopoly supply companies do exist and are often government owned and operated, but they are unreliable. Independent small distribution and supply companies offer an alternative and may come to exist, but in some countries, such as India, private free-market suppliers of electricity are illegal. Unlike the franchised monopoly supplier, such spontaneous companies can exist only if they provide a reliable supply. Typically, such insurgent companies charge higher prices than their government competitors yet are paid, while the government monopoly is often not paid at all.

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The presence of such insurgents in developing economies contradicts nearly all of the classical doctrines of utility regulation. The licensed supplier may have a legal monopoly but has none of the properties of a natural monopoly. The presumably less expensive (and heavily regulated) network costs per unit of output do not necessarily induce consumers to *voluntarily* buy the regulated monopoly provider's electricity. Even in the presence of such a network—and despite government programs to "help poor people" by setting low prices—consumers turn to more expensive but reliable alternatives, such as kerosene, which have no natural monopoly technology attached to them.

Many countries have by now experienced the effects of energy development projects that did not adequately consider reliability in the design of operational systems. The credibility and effectiveness of development advice will depend on the willingness to recognize and deal with reliability issues and their costs.

Resilient Self-Sustaining Energy Development

People in the developed and much of the developing world have access to electricity usually through a local distribution company, which may also provide the supply. Yet, the *World Energy Outlook 2010* (OECD/IEA 2010: 56) estimates that 1.4 billion people are not connected to grids and 2.7 billion people use biomass for heating and cooking. Many of those have kerosene as a principal source of light and heat. Moreover, world electricity demand is expected to increase by 2.2 percent annually, with 80 percent of that demand coming from non-OECD countries. If we also consider transport, the effect on demand for electricity generation can be even more profound. Aggressive scenarios assume that 75–80 percent of all vehicles will be electric by 2035 (OECD/IEA 2010: 218). Moreover, the developing world may be consuming about 50 percent more electricity annually than OECD countries. Even in the low carbon scenarios, which assume aggressive energy efficiency programs, a substantial amount of traditional energy will still be used. Part of the growth in electricity demand in the developing world would likely come from conversion from kerosene to electricity. These facts, and others, mean that a free-market energy policy may achieve resilient growth while serving the unserved.

The pattern of presently served electricity markets in developing countries is well documented. Typically, a single monopoly distribution company provides retail delivery services. Probably that company is still or was recently owned by the government. There is an existing high-voltage transmission system, which is almost certainly also a monopoly and probably owned by the government. There are established sources of generation, which if not already organized for wholesale competition are being pushed in that direction. The size and density of these established markets provide a comparatively low average cost for delivery and generation of electricity, which may induce some monopolistic behavior. The traditional case for electricity regulation stems from dealing with that possibility.

It may therefore be counterintuitive that the provision of energy and electricity to the 1.4 billion unserved is instead a comparatively competitive market. The costs and unit prices encountered are much higher, because the technologies used lack economies of scale, the fuels are higher cost, and they are often small systems that are comparatively capital intensive per unit of output. High capital costs and other reasons can prevent established grid systems from expanding to serve these markets. Thus, these markets generally lack the monopolistic characteristics of established natural monopoly networks. These differences can govern not only the immediate- and medium-term economic solutions but also the kinds of regulatory issues that may arise. Such differences explain why many of the solutions discussed in this article are not simply copies of the traditional forms found in more established and natural monopoly markets.

Many examples exist of effective creation of electricity services in off-grid applications in the developing world. Most often those examples of nontraditional solutions are not even documented in official statistics. For example, Soluz, Inc. (www.soluzusa.com) developed and operates off-grid solar energy distribution systems in Honduras and the Dominican Republic on a wholly commercial basis. In Afghanistan, self-capitalized local electricity distribution and supply companies help deliver reliable supply, as I witnessed in 2009 during a USAID-funded Economic Governance and Growth Initiative project. Those companies operated profitably with high collection rates at prices similar to the highly subsidized yet unreliable and insolvent government company to about 2,000–3,000 consumers located immediately adjacent to or even concurrently with territories of the government company. A similar phenomenon has been documented widely in post-conflict countries (Schwartz et al. 2004: 7). In Bangladesh, Grameen Shakti financed over 285,000 small Solar House Systems by the end of 2009 at "the same cost of kerosene," on a commercial basis for individuals and communities (Rabbi 2009: 12). Competitive forces driving energy development are also visible across sectors. Telecommunications towers in the rapidly growing mobile phone industry in India are combined with solar PV systems (Hamilton 2010: 34). A study by Global Village Energy Partnership (GVEP) International (Rai and McDonald 2009: 10, 17, 31) demonstrated substitution of LPG for more polluting biomass sources in Sudan, with similar activities improving cookstoves using renewable energy distribution channels, in India, Latin America, and Africa. Consistent with all these examples and many others, a University of Manchester study of electrification in developing countries found that competition in provision of distribution and of supply is the key driver of electrification (Zhang and Kirkpatrick 2002: 1).

Reliability Leads to Customer Confidence

If competition drives expansion of electrification, how can private entities survive when all of their customers are presumed to be poor? The answer is surprisingly simple: People, including poor people, buy, and are only willing to pay for, the availability of electricity on demand. In the absence of reliable grid power systems, consumers may substitute other sources, such as diesel or gasoline-driven small generation sets to provide reliability or even a large portion of the actually delivered total supply. Very often in more remote areas with many poor people, an alternative supply of lighting comes from kerosene, which is relatively expensive and also highly polluting. That many of these consumers are poor implies that a common presumption that poor people cannot pay for electricity is false. Instead, the facts demonstrate that even poor people are willing to pay for reliable lighting, which is what kerosene represents.

According to the World Bank (2009: 13), a rural household in India "consumes an average of 4 liters of kerosene per month for lighting." In rural Afghanistan, kerosene lamps account "for approximately 86 percent of lighting" even though "this lighting source is costly, inefficient, polluting, and provides poor quality light." The World Bank (2010a: 88) also found that only 3 percent of the rural households of Bangladesh gain access to the grid each year, leaving about 14 million people with no access. Thus, 70 percent of all rural lighting comes from kerosene.

Reliability is the key to making low-carbon or any other energy a foundation for "climate resilient" growth. For poor people, kerosene has the advantage that it is available when needed. Since users of kerosene are paying cash, one may expect, and our earlier examples show, that they would also pay cash if equally reliable lighting were available as electricity, at prices not higher than equivalent lighting from kerosene. The problem of providing distributed generation, while reducing the use of kerosene for lighting, is thus not likely to stem from poverty.

We can make a simple comparison of the cost of kerosene relative to electricity for lighting. Following the above cited World Bank data, let us assume that an average unserved poor family uses 4 liters/month of kerosene for lighting at a price of about $1.90/liter, or about $7.50/month. Assume a very high electricity price of $0.50/kwh, which is comparable to the unit prices for many renewables, as demonstrated by the studies of the World Bank's ESMAP project as summarized in Table 1. For the same outlay, a family could

TABLE 1
Range of Cost per Kilowatt Hour for Renewable Energy Sources, 2010

Technology	Cost ($/kWh)
Solar PV	0.366–0.556
Wind	0.050–0.320
Wind-PV Hybrid	0.278–0.378
Geothermal	0.041–0.145
Biomass/Biogas	0.066–0.094
Micro Hydro	0.042–0.145
Pump Storage	0.340
Diesel Genset	0.190–0.597
Microturbines	0.307
Fuel Cells	0.127–0.247
Solar PV	0.366–0.556

Source: World Bank (2010a: Table A24.1).

buy 7.50/0.50 = 15 kwh/month of electricity or 180 kwh/year. This is approximately one 40 watt bulb running for 15,000wh/40w or about 370 hours each month. Since an average month has 730 hours, this represents a single bulb operating for about 50 percent of all hours, which is a typical or even fairly high residential load factor.

Most of the unit costs for renewables shown in Table 1 are substantially less than $0.50/kwh. Thus, in all those cases, even a poor household could buy much more electricity than this calculation illustrates. Consequently, even with high delivered local energy costs, poor people could improve their quality of lighting—provided that *reliable* electricity supplies were available. At lower electricity prices, more energy for the same energy budget, or savings in total energy costs, could occur. The result is not only an economic benefit but an improvement in the quality of lighting and a better household environment (World Bank 2010: 39–42 and Annex 3).

Problems of Capital Misallocation

The examples we have given show instances where private capital has effectively undertaken development (see also Stockholm Environment Institute 2010: Appendix 6). But capital misallocations can occur in diverse ways in advocacy for supporting the 1.4 billion unserved, including many poor people in developing countries. Allowing capital to flow to where it has higher-valued uses, as determined by consumers, is also an important factor for continued development. The *World Energy Outlook 2010* (OECD/IEA 2010: 52) notes that because "renewables are generally more capital intensive than fossil fuels," the estimated capital costs of simply meeting renewable energy production will be $5.7 trillion through 2035. Moreover, it is estimated that the incremental annual capital cost of providing universal access to electricity by 2030 would be another $36 billion per year.

Those aggregated funding requirements, however, can be misleading. They reflect an estimated sum of all of the capital presumed to be invested by the operators. In practice, there are many separate investment decisions. These range from those of a single household to larger systems requiring thousands or millions of dollars each, and much larger capital projects. Each is decided on its merits by the people, the companies, and the governments immediately involved. However, based on such projections, some significant special purpose funds have been created and managed by multilateral development banks and other governmental sources of funds. Many MDB funds intend to "leverage" funds from presumably private sources. Creation in October 2008 of the $6.3 billion Clean Technology Fund, supported by 11 European countries, led to establishment of the Climate Investment Fund administered by the consortium of the World Bank, African Development Bank, Asian Development Bank, InterAmerican Development Bank, and World Bank. The CIF has led 13 countries to date (including Colombia, Egypt, Indonesia, Kazakhstan, Mexico, Morocco, Philippines, South Africa, Thailand, Turkey, Ukraine, and Vietnam, as well as a Concentrated Solar Power fund for the Middle East and North Africa and a Strategic Program for Climate Resilience for Bangladesh) to establish CIF Investment Plans. Such programs have heavy bureaucratic requirements. To use such funds, and to achieve specific policy purposes in clean energy, many countries have adopted the necessary National Adaptation Program of Action or National Appropriate Mitigation Plan, but plans are not the same as implemented results. Reducing deforestation, often a result of harvesting for heating and cooking fuels in developing countries, and increasing reforestation are targeted by special funds of the World Bank Carbon Partnership Facility, including the Carbon Asset Development Fund and Forest Carbon Partnership Facility.

The REDD (Reducing Emissions from Deforestation and Degradation) approach is gaining interest, such as Norway's $1 billion effort in Indonesia. USAID's website tells us that their Credit Development Authority has so far approved over $2 billion in lending through credit guarantee arrangements with private financial institutions. The total funds from all of the foregoing programs is $9.3 billion. But that amount is less than two-tenths of 1 percent of the estimated $5.7 trillion needed for capital projects to increase electricity access for the underserved. Plainly the solution to the access problem will not come from MDB funding.

Targeted price subsidies also can misdirect capital. Governments often offer direct subsidies to reduce electricity tariffs or other fuel supply prices. The justification stated is typically to "help poor people," but often it is instead favored elites, not the poor, who benefit (World Bank 2010b: 93). A World Bank study (2005: 142, 170) gives examples of how subsidies that claim to target the poor may deliver most of the benefits to non-poor. For example, in Nicaragua

80 percent of the benefits of a tariff subsidy for grid electricity went to the non-poor, while the portion of the poor who received the remaining 20 percent constituted only about half of the poor population. A program truly targeted for the poor would have cost about 60 percent less. To be fair, the World Bank study (2005: 172) did conclude that such subsidies as reach the poor do have a "mildly favorable" impact. But since most benefits may not reach poor people, the total cost of that impact may be many times the impact delivered. Consequently, subsidies are an inefficient way to deliver the intended result. Since most of the 1.4 billion unserved are not connected to networks, or if connected don't have a reliable supply of electricity, most of the unserved do not benefit from such subsidies.

One means to improve prospects both for normal competitive development of electricity supply and for clean energy may be to remove direct and indirect fuel subsidies (as suggested for example by International Institute for Sustainable Development 2010a). The *World Energy Outlook 2010* (OECD/IEA 2010: 569) estimated that in 2009 total fuel subsidies were $312 billion, and found that for 25 developing countries fuel subsidies ranged from about 1 percent to over 30 percent of GDP; this is comparable in aggregate to the investment required in the next decades for new generating capacity. The Global Subsidies Initiative of the International Institute for Sustainable Development (2010b: 13ff) found that China, Saudi Arabia, India, Venezuela, Indonesia, Egypt, and Ukraine had "annual subsidies in excess of $10 billion per year," and that "oil products were the most heavily subsidized of fossil fuels at $152 billion per year in 2007." The IISD also reported that in 2006 subsidies for natural gas reached about $70 billion and for coal about $10 billion. These data show that such subsidies can be a significant part of national budgets in developing countries. Indeed, the IISD study concludes that "in many countries, particularly developing countries with low GDP per capita, consumption-related fuel subsidies have exceeded 2 percent of GDP for many years. Notable examples include Turkmenistan (15.2 percent of GDP in 2008), Ecuador (8.7 percent), Egypt (8.4 percent), Ukraine (3.3 percent), and Bangladesh (3.0 percent)." For many of those countries, the IISD found that "expenditures relating to the subsidization of fuels were as large as or larger than health or public-education budgets, or both in some cases."

Abolishing such subsidies is possible, as was done in the Philippines in 1998, Malaysia in 2010, and is now being attempted in Indonesia and India. Removing subsidies for favored fuels can greatly enhance the ability for private suppliers to provide sustainable electricity and heating.

Issues of Market Evolution

Our initial focus is on competition among lighting suppliers at the point of retail consumption. In certain senses the evolution of that market is predictable. If and when smaller local grid systems come to exist, there are compelling economic reasons why such systems will probably not remain unconnected. Reliability of supply is greater on larger and more diverse networks, and the cost of procuring that reliability is less than on smaller networks.

The simple economics of electricity supply therefore tells us these systems will likely voluntarily inter-tie. Larger connected retail markets may attract creation of lower-cost generation sources that require economies of scale. Moreover, larger inter-tied markets may have more generation choices and more competition leading to lower prices. Those simple facts of economics will likely lead smaller distribution systems to seek interconnection, which would allow them to tie to larger-scale generating plants, and replace undesired or high-cost sources with lower-cost sources. Such a progressive substitution path is exactly how smaller systems became larger integrated grids in the initial development of power systems in many developed countries. When there is a sufficient density of inter-tied local distributors, their aggregated volumes would allow larger (and lower-cost) generators to compete for supply.

The foregoing has important implications for technical issues that affect other economic choices. If small grids are isolated from each other, each can select its own technical operating standards, such as voltage and frequency. But if any two systems seek to connect, they must share the same technical standard. So let us consider the issue of technical standards a bit more deeply.

Much of the business of providing electricity services is carried out by interconnections using alternating current power. AC connections have special technical requirements: changes in certain conditions on any part of such a network are instantaneously transmitted over the entire system due to the physics of AC. Thus, all users connected to such a network must meet the same technical standards to assure that each does not harm the others. Nothing in the foregoing discussion, or in the empirical examples cited earlier, provides the means of assuring such protection. The problem is more serious as smaller networks congeal into larger grids. The cost of adopting common AC standards at later stages can be very high, perhaps prohibitive, since it may require changing much of the equipment already by then in place. The creation of a growing base of retail consumers also implies creation of a larger potential volume of sales and lower cost generation. (By "larger" here we mean generation units of more than just a few MW for a small local network.) Private development of larger generation will likely depend on potential investors and operators knowing they can get access to the retail or distributor markets, or to the distributors themselves as customers. In this scenario, access is a physical issue: the generator needs to know the voltage level and frequency standards for interconnection, and know they are maintained.

Thus, an issue that arises at the outset of such a market is the standards defining equipment and operations, such as voltage and frequency. On AC systems, this implies a necessity for a regulatory condition requiring that all interconnected devices and companies must meet the same technical standards and define those standards.

A direct current interconnection may not have the same physical risks as an AC system. This distinction is important, as it implies different solutions. Small private distribution systems may initially self-generate electricity from high-cost sources. They may lack the capital for conversion to some subsequently established AC standard. They, and their consumers, might prefer lower-cost electricity supply, which could be made available only through connection to larger networks. Therefore, some small distribution companies might prefer to use DC connections to inter-tie to larger alternating current networks, avoiding the cost of meeting the AC connection standards. This could avoid the cost of conversion of a whole local grid. A regulatory system treating technical standards should be aware of and might allow for this possibility. Doing so may lessen some of the effects of distinct standards among diverse small systems.

This observation may be counterintuitive to those looking only at established integrated networks. But physical devices that make this possible are already well known and widely used, though often for other purposes. Examples are inverters and backup systems using a DC interface that many consumers create for their own reliability of supply when they are on larger but badly operated grid power systems. DC inter-ties are also growing in use between AC systems of differing technical quality in Eurasia and with differing regulatory philosophies, such as between the Electric Reliability Council of Texas (ERCOT) and other adjacent grids in North America (see Steering Committee of Cities 2011: 19 and United Nations 2005: 29 ff).

Eventually local grids may become sufficiently connected to form an enticingly large aggregate load. The presence of such load may naturally attract special marketing companies. Such companies might own no distribution or transmission plant, but simply seek to sell "supply." In some cases these may be agents for particular generators. Some might be companies who find smaller sources of generation and aggregate them into larger "packages," which allows better use of the generation potential while reducing the cost of finding and making transactions. This approach implies having rights for access to use distribution grids and transmission networks while paying fair prices for such use. The aggregate result would be a system of higher reliability and lower average unit costs. In fact, the overall result would also be a system capable of uses that require higher capacity in application, such as for replacing biomass for heating and cooking, and for allowing use of power tools by small businesses or craftsmen, which isolated small systems, or small systems run only on low-amperage renewable generation, do not otherwise permit.

The apparent simplicity of the purely technical issue of interconnection standards for AC systems does not demean its importance. Established regional systems and markets implicitly assume the existence of technical standards. The market reform issues often discussed in relation to such markets also assume a preexisting physical network, which is being opened for broader uses. But the initial condition of the unserved markets is instead one of fully open retail competition, where there is no preexisting established physical grid network. Part of our regulatory problem is therefore to determine that initial steps do not prohibit more sophisticated transition issues being resolved later, if they arise. Properly managed, including the consideration of DC inter-ties, the path of evolution might avoid their existence at all, and allow a more competitive structure of the overall market.

Regulatory Issues

The traditional problem often called "electricity regulation" is to govern services from an established monopolistic electricity supplier. The lack of a dominant utility is however the *World Energy Outlook*'s defining condition for the 1.4 billion without access for electricity.[1] Thus, the regulatory issues that may arise are different from those of traditional utility service as a mandated monopoly. Those issues, and their beneficial effects by treating them as issues of competition, have been studied in some depth. For example, the UNCTAD survey (Qaqaya and Lipimile 2008) shows how competition policies aid development, and Fox (2007) argues that the preferred policy mechanism is competition law, not direct controls.

In this article, we have shown by empirical examples that markets, not monopoly, can best serve the unserved. Consumers of kerosene, and consumers of biomass, if not simply collecting biomass, are likely buying their energy at retail on an open market.[2] The energy they employ is available from suppliers who are not natural monopolies and may not be licensed in any form. Indeed, the provider is probably not a member of any network. Kerosene allows for distributed lighting in the sense that each light source is itself completely self-contained with its energy source. We earlier cited examples of businesses that provide a household or small business with the means for a completely self-contained system for self-generation of electricity. In other cases, a small local distribution company provides the service from local sources of generation. In these cases, the market in question is that which can compete with kerosene for local lighting. It is a retail market and typically not part of an integrated larger connected grid. Operators have no legally protected right to an exclusive market and face actual retail competition at all times. If and when such a market evolves to become a local distribution grid, and eventually part of a larger electricity transmission network, then more

[1]We do not here discuss reform of existing systems. But certainly within the large number of unserved are also countries or parts of countries that have attempted to resolve the service issue in that form but have not succeeded.

[2]In some cases, a government has chosen to subsidize some particular fuel. We have separately noticed the urgency of government to remove such subsidies as crippling to national budgets, counterproductive to creating self-sustaining electricity systems, and certainly contrary to allowing renewables access to markets on fair and competitive terms.

traditional regulatory issues may arise. But the immediate condition, which is the condition that may make solutions possible, is one of an open retail market. The regulatory problems to be solved initially are therefore dictated principally by the structure of that market. The principal fuel used for lighting by the unserved is kerosene, purchased for cash. The definition of the market can be taken as that for purchasing or selling any electricity service or device that can deliver lighting that is at least as reliable as kerosene and not more expensive. Because electricity is also much cleaner than kerosene and delivers a much better quality light, it will likely be adopted in place of kerosene if it can be delivered with equivalent (or better) reliability at the same or lower price.

In an important sense, this condition is self-regulated by the market. In such cases, the motivation for the consumer, household, or small business is cost-effective conversion from kerosene, and its unpleasant effects on immediate environments, to cleaner forms of electricity. Assuming electricity is available under the conditions stated, it will likely be adopted by consumers. Examples were noted where private grid operators noticed an opportunity and entered such markets effectively, without the assurances provided by traditional forms of exclusive markets. Our examples also showed cases where private enterprises, encouraged by various donor devices, entered such markets and effectively provided electricity services—or they created retail businesses whose product is the means for households to create their own electricity.

Traditional regulation often assumes that distribution companies have been assigned exclusive territories. Nothing in the empirical examples cited here required exclusive territories. So long as the market is defined by competition with kerosene, then any technology and business organization that can meet the competition is a potential entrant. As for any retail market, consumers make choices freely from potentially many alternative suppliers. Their consumers may be in a preferred position than if they took only kerosene, and indeed may make such a choice voluntarily. One argument often made in favor of requiring exclusive licenses is that there are economies of scale to common operation of a larger network. But this outcome can also likely be achieved without requiring exclusive territories. For example, an electric service company might share use of its facilities with other such companies via an agreement on how to share the common costs of facilities. Such provision could enable benefits of having a single integrated system even when parts of it have different owners and operators. It may well turn out that different companies principally serve different territories. But the market that reaches that result by fair and open competition, and which remains open, ought not induce superposition of a traditional regulatory structures.

The Access Problem Has a Market Solution

The fact that a long history of designing solutions for expanded electrification in many developing countries has not produced wider electrification implies that different forms of thinking must be found and applied. Common presumptions of development advice may not be true. We outlined an alternative that may help solve the problems of reliable and affordable electricity supply to the unserved. This article suggests a way to develop a reliable system with declining costs based on markets, not the state. Our approach, in fact, mirrors how other network industries have been created. The concept of a spontaneous order in the provision of electricity to the unserved is compatible with a number of studies of electrification in developing countries where it has been found that free-market competition is a better driver of electrification than government monopolies.

The conventional wisdom is that "poor people cannot pay for electricity." But the evidence is that even poor people will likely pay for a *reliable* supply of electricity. Poor people already pay for kerosene to provide reliable, if low quality, lighting on demand. Since poor people do buy kerosene, there is no basis to assume they would not buy electricity if it were available at the same or lower cost, and were at least as reliable as kerosene. Though electricity volumes in a local system may initially be small on a pure substitution basis at such costs, this implies a strategy of building distributed local generation, initially using any available fuels, to serve what are initially isolated smaller local distribution systems. Costs may be initially high, but not higher than kerosene. As distribution networks are created and grow, supply costs will decrease for several reasons. As local systems grow and can become interconnected, total retail demand grows on the combined network, and so the cost of bringing larger-scale generation with lower energy costs can justify building those units. Since those units have lower costs, one can expect demand (total volumes sold) to grow even more.

This expected outcome is true even for poor people: as price falls, the same budgets can cover more electricity and allow more uses of that restricted budget. This places an incentive on privately operated distribution systems to attach as many customers as they can. Doing so provides the base on which load growth can occur, which increases the potential for profits distributors earn by selling delivery services. As lower-cost electricity is justified and available to replace the high-cost sources, higher fuel-cost generation equipment, and especially that using diesel, can be removed. At the initial stages, substitution for kerosene offsets use of that undesirable fuel. In its place may be a mix using some diesel fuel. But the result of substitution reduces a polluting fuel. The actual initial mix is lower in emissions than the kerosene it offsets. Later development of the network could rely on more efficient larger-scale generation sources, further reducing emissions and also costs.

A very similar phenomenon occurs on power systems providing regulated network services. A very common condition is that such services are priced well below their real costs, on the claim that poor people cannot pay for electricity. As a result, two things may happen. First, the electric company is typically made economically unviable and is unable to provide reliable service, causing consumers to not pay despite "low" prices and further deteriorating the utility's financial condition. Second, poor people may install and operate portable backup generation, often powered by gasoline or diesel fuels at very high per kwh cash costs. The extensive use of such devices throughout the developing world—often the principal sources of actually consumed electricity even when public utility networks are present—definitively demonstrates two things: (1) poor people can and will likely pay much higher prices for electricity than is assumed, and (2) natural monopoly does not exist in electricity supply in a vast swath of the world purportedly already supplied with regulated grid electricity. Most of the arguments given in this article apply equally to the regulated dominant markets affecting many more consumers than simply the 1.4 billion unserved.

Conclusion

The recent large-scale power outages in India demonstrate that the ideas presented in this article are also applicable for large-scale grid systems. Our principal premise is that electricity consumers pay for *reliability*, including availability when desired, not simply for volumes of electricity; and that such reliability can be provided by many nontraditional devices. Even in areas of India that have grid service, the service provided is often so unreliable that consumers and industries commonly maintain their own diesel fueled backup units, and may use those for hours on many days (Lavell et al. 2012). While the regulated grid prices therefore may be "cheap" for political reasons, and the grid companies (typically state owned) are heavily subsidized, the regulated prices do not reflect the real cost consumers in fact incur. Since the capital cost of those backup units must be amortized over the hours they are actually used, in addition to the cost of the fuel, consumers are paying many times the regulated price for backup power to assure reliability. Therefore, even in locations where the official price is regulated, the real price is much higher than the regulated price. Moreover, those markets are not natural monopolies, despite the presence of regulation of principal suppliers.

While much of India lies within grids, the unreliability of those grids means that interconnecting them by AC devices adds risk rather than assuring reliability. Consequently, extensive actual construction of and plans for more DC transmission connections that isolate connected grids from each other's instabilities are under way across India, and even more so in China (Runte 2012). Our proposal to allow distributed generation in local distribution systems to evolve as local economic conditions warrant, and then deal with interconnection using DC not AC devices, is already in practice on high-voltage grids in India.

This article has described a path for serving the unserved using market principles, which is decidedly superior to state monopolies in terms of reliability. The unserved in India and other developing countries should be given a wider range of choice in electricity, as opposed to the bureaucratic stagnation and unreliability they face today under government provision.

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