Issue Brief

ACCESS TO ELECTRICITY IN DEVELOPING COUNTRIES

ELECTRICITY, POVERTY AND SUSTAINABLE DEVELOPMENT

Context

There are two main elements to access to electricity:

1. *Electricity supply in the home*;
2. Sufficient *electricity supply to business and organizations*, allowing:
   - Existing business to work to its full potential and new business to be set up;
   - The development and strengthening of institutions necessary for social development, e.g., schools, hospitals and government buildings.

It is electricity supply in the home, and the benefits it brings to health and quality of life, which has received the most attention. However ensuring sufficient electricity supply to allow business to flourish, driving development and wealth creation, is also vitally important. Not only does business create jobs, the tariffs it pays are an essential source of income for the electricity supplier.

Electrification is not just a technical problem. A range of other factors, including social, legal, financial and economic, also have a key role to play in the optimum design and delivery of a scheme (see section on *Implementing electrification schemes*).

Electricity use in poor households

Electricity will not provide the full range of energy services to households currently without access. In the poorest households, biomass (wood, charcoal, etc.) is generally used for cooking and heating with candles and batteries used for lighting. As income increases, modern energy sources (kerosene, liquified petroleum gas (LPG) and diesel) replace biomass and candles. When available, electricity is expensive relative to these fuels and its use in poor households tends to be reserved for applications where it vastly improves services, notably lighting and communication (e.g., radios). New appliances such as refrigeration and television will come as income levels increase further. Once households have electricity, there is a wide range of evidence that they treat it as a necessity and are willing to preferentially devote their disposable income to maintaining their electricity supply. Between households, electricity usage varies widely by income level.

The link between electrification and income

A lack of electricity and heavy reliance on traditional biomass are hallmarks of poverty in developing countries. Access to electricity is a necessary, but not sufficient, condition for poverty alleviation. Access to other modern energy sources is also required, as are clean water, adequate sanitation and health services, a good education and a communications network. Without electricity, poverty is exacerbated and perpetuated: most industrial, income-generating activities are precluded, and thus jobs are not created; without the longer access to lighting that electricity provides, education, study and evening work are constrained; refrigeration allows long-term storage of both healthcare products and food.

The higher the percentage of the population with a low income (under US$ 2/day), the lower the electrification rate. Income provides a much better predictor of levels of both electricity access and consumption than a country's stock of indigenous primary resources. Income is however not the only factor: over half China's population has an income under US$ 2/day but, due to a major electrification program over the past 20 years, over 95% of the population has access to electricity.[1] Similarly, South Africa has also achieved a rapid increase in electrification rates over the past

15 years. In both cases, electrification has been identified as a key political goal and programs have been designed and implemented to achieve this goal. Stimulating business and economic output was one of the key reasons for supporting electrification.

Electricity's contribution to sustainable development

The benefits of access to electricity and other modern energy sources are large, particularly for the poor. Electrification contributes to the three pillars of sustainable development by being an important driver of economic development and social progress while also benefiting the environment. The first of the Millennium Development Goals (MDGs) adopted by the UN in 2000 was to eradicate extreme poverty. One of the two targets is halving the proportion of the population living on less than US$ 1/day by 2015. The strong link between low income per capita and low electrification rates implies that increasing access to electricity will be a key part of meeting this target. The benefits of access to modern energy sources, including electricity, are an important input to achieving many of the eight MDGs:

1. Eradicate extreme poverty and hunger;
2. Achieve universal primary education;
3. Promote gender equality and empower women;
4. Reduce child mortality;
5. Improve maternal health;
6. Combat HIV/AIDS, malaria, and other diseases;
7. Ensure environmental sustainability;
8. Develop a global partnership for development.

The G8 summit in Gleneagles in 2005 reaffirmed energy's key role, *"We need to work with our partners to increase access to energy if we are to support the achievement of the goals agreed at the Millennium Summit in 2000."*

LEVEL OF ACCESS TO ELECTRICITY

Electricity supply to business and organizations

For this category, reliable, consolidated statistics are not available. Nevertheless there is widespread evidence from around the world of the importance of developing electricity supply to business:

- "Blackouts" (unplanned cuts or the delivery of electricity outside design parameters of voltage and/or frequency) and electricity rationing or "brownouts" (planned cuts, whose timing is generally advertised in advance) are seen in many countries (e.g., parts of China, Asia, Africa and the former Soviet Union). They result in substantial costs to business and reduce their willingness to pay for the service they receive. They act as a significant constraint to business output and development.
- Development studies have clearly illustrated the difference in economic output and growth between those regions where business is adequately supplied with electricity and those where it is not.

Electricity supply in the home

A note on available statistics

Statistics on electricity supply to the home differ both by how they are collected and under what principles. Key variations are a result of the following factors:

- In certain countries, an electricity connection to one home in a village is interpreted as being proof that the whole village is electrified. In other countries, an assessment is made at the level of the home.
- Statistics generally relate only to authorized (metered) connections. In certain countries (e.g., parts of India), there are high numbers of unauthorized (unmetered) connections.
- Having a connection does not necessarily mean that electricity is being supplied:
  - The electricity utility may not have sufficient supply for all consumers, and at all times;
  - Customers with connections may choose not to use them (typically for fear of others illegally tapping into their supply and thus increasing their bills).

Statistics[2]

1.6 billion people (27% of the world's population) had no access to residential electricity[3] in 2002. Of these:

- Over 99% live in the developing world;
- 80% live in rural areas.

Approximately half of those without access live in South Asia (with over 70% of these in India, the region's most populous country). The population of sub-Saharan Africa includes over 500 million people without access, and that of East Asia over 200 million. These three regions account for almost 95% of all those without access – access rates are 100% in the OECD (other than in Turkey and Mexico, where rates are 95%) and over 85% in most other countries (including China, where the figure is approaching 99%).

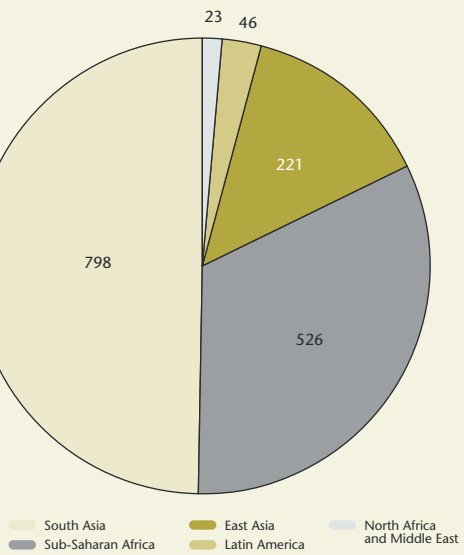

Figure 1: People without access to electricity (2002, millions)

Source: International Energy Agency. *World Energy Outlook 2004.*

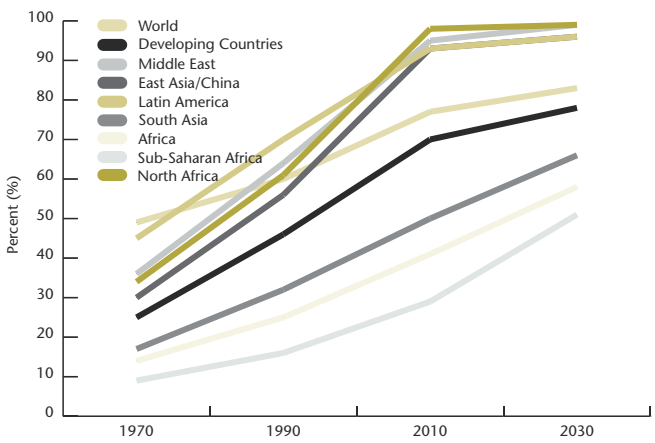

Figure 2: Electrification rates around the world (urban and rural populations)

Source: 1970 and 1990 data, IEA, World Economic Outlook 2002; 2010 and 2030 data, IEA, World Economic Outlook 2004.

IMPLEMENTING ELECTRIFICATION SCHEMES

Understanding the challenge

Electrification has increased rapidly over the past 30 years. Only 49% of the world's population had access to electricity in 1970. By 1990 it had increased to almost 60%, and it was 74% in 2002. Rates of access have increased in all world regions but remain very low in sub-Saharan Africa (24% in 2002), Africa (36%) and South Asia (43%).

International Energy Agency (IEA) projections for the next 30 years see increasing prosperity and more advanced technology in all world regions. "Without vigorous new policies", they project that 1.4 billion people in 2030 will be without electricity. This is 200 million less than the current level despite a projected rise in population from 6.1 to 8.2 billion over the period: the rate of electrification is projected to rise from 73% to 83% worldwide, with an average of 75 million people newly connected each year. The key driver is that 95% of the projected increase in population in the next 30 years will be in urban areas, which are largely electrified at present (over 85% in the developing world in 2002). The IEA projections assume that electricity will be supplied to the vast majority of the world's new urban populations, many of whom will be relatively poor.

Increasing electrification rates beyond the 83% projected by the IEA will depend on the success of increasing access in rural areas: only 52% of the developing world's rural population had access to electricity in 2002, with only 8.4% in sub-Saharan Africa and 32.5% in South Asia.

There is no single way to provide access to electricity. Technical factors are not the only consideration: a wide range of social, legal, financial and economic factors can have a major impact. The key factors influencing the design and delivery of electrification schemes are:

- Possibility of linking the existing grid (driven both by the distance to the grid and its capacity to supply extra electricity);
- Potential electricity demand (from residential, services and business consumers);
- Relative level of development in the area;
- Structure of the electricity sector and other parts of the economy;
- Legal and regulatory constraints;
- Customer and community relations;
- Access to natural resources;
- Affordability.

Where available, the *possibility of linking to the existing grid* is almost always the best option. The grid provides a range of services (voltage and frequency control, reliability, reserve, ability to use a wide variety of generation technologies) that would otherwise have to be duplicated, and thus paid for.

Higher *potential electricity demand* generally allows more sophisticated systems with better levels of service to be provided. There is a large fixed cost element to infrastructure

development, which means that average costs per unit of electricity delivered are lower if demand is higher.

The *relative level of development in the area* is an important consideration when assessing possible population movement. People tend to migrate to newly electrified areas from those that continue to have no access. This can impose unsustainable demands on resources. There is a need to ensure balanced development of electrification, particularly if there are already concerns about the rural population migrating to urban areas.

A number of constraints could result from the *structure of the electricity sector and other parts of the economy*, from *legal and regulatory constraints* and from c*ustomer and community relations*. The structure of the electricity sector may be highly centralized, with subsidized tariffs applying to all residential consumers; this could prove a barrier to electrification. Increased levels of local autonomy could better support electrification, although the centralized system in China has delivered electrification across the country. The key to understanding the problem lies in working out who is able, and willing, to do what. A vital part of program design is a community's attitude to electrification. This is driven by the local situation and previous knowledge of electrification. Once customers have electricity, they desire more: but without increased levels of information, they often do not have adequate knowledge to make the best choices.

Access to natural resources acts as a further constraint. First, it defines the fuels that electricity and other modern fuels would displace; second, electricity generation using local energy resources may have a cost and sustainability advantage when compared to modern fuels; last, a country's general wealth of natural resources is also important – many new customers will be connected by extending the existing grid, and the availability of coal, large hydro or other large generation options will minimize the costs of the additional generation required.

Perhaps the key factors are *affordability and sustainability*: schemes must be designed such that communities can consistently make payments over long periods. It is only in this way that utilities can make a profit and can continue to invest. Load should be limited to what the community can afford and customers should be given a set of payment options, with the ability to upgrade as their income increases. Prepayment meters are a vital part of many schemes. Only affordable schemes can be sustained over the long term.

On-grid or off-grid?

For locations close to existing grids that can deliver extra supplies reliably, extending this grid is almost always the best option. It is important to note that existing grids in certain locations cannot deliver electricity reliably to their current customers, yet alone to new ones.

For example, demand for grid-based electricity from Indian industry as a whole is currently falling – the service is not good enough for many customers who are choosing to auto-generate their own electricity. This generally uses medium sized (50 MW) coal plants, delivering electricity at around 5 US cents/kWh. Integrating these relatively small, distributed generators into the electricity grid in the future would represent a major challenge, not least as their capital costs could become "stranded" (i.e., there would be insufficient revenue to pay off the capital charge).

For locations far from existing grids, it will be better to develop "mini-grids" if demand is relatively high or to use "off-grid" solutions for lower demand. The key driver needs to be affordability. Extending existing electricity grids in urban areas is relatively cheap and the average income of those connected is relatively high; new networks in rural areas, powered by decentralized generators, are relatively expensive per household connected and the average income per household is low. Extending existing electricity grids is both a more attractive investment to utilities and their partners and results in more new households connected per dollar invested. The further off-grid, the more expensive new connections become. There are gray areas, but in general the optimal choice is reasonably clear – the relative costs and benefits of "on-grid" and "off-grid" solutions give good guidance in the majority of cases.

It is important to note the differing levels of service offered by grid extension, mini-grids and off-grid solutions. On-grid solutions tend to provide higher service levels (higher availability and reliability), along with lower maintenance requirements. Off-grid solutions in small networks may offer only intermittent generation, with insufficient storage or reserve capacity to provide continuous electricity supply. Customers perceive off-grid solutions to be inferior. Sustaining maintenance over the longer term tends to be straightforward with on-grid systems. Under certain off-grid models (e.g., fee-for-service, long-term concessions), it is relatively easy to sustain maintenance. The application of other models (e.g., retail models) can offer fewer guarantees that maintenance will be continued - it is essential that maintenance of the equipment and replacement of used

parts such as batteries be planned as an integrated part of the electrification program.

Most new connections are on-grid, and will be undertaken by utilities. These utilities will generally be monolithic in structure (responsible for all aspects of electricity from generation to transmission and distribution), and operate in non-competitive environments.

Experience has shown that off-grid developments benefit from early consultation with the community, principally to assess their needs and income but also to establish fuel choices (e.g., the community may have the resources to produce biodiesel).

Generation options

All new demand will require increased generation. For on-grid solutions, large-scale conventional fuels and technologies are likely to be the best option, although the grid offers an ideal vehicle for introducing renewables whose generation may be intermittent. Diesel or LPG engines may offer the most cost-effective solution for mini-grids and off-grid systems, alone or in combination with renewables (wind, biomass, small hydro, solar photovoltaics).

Renewables can be the best option for certain mini-grid or off-grid cases, but there is no definitive link that shows that small schemes should always use renewables. Diesel or LPG may offer lower costs and higher availability, and this may more than offset increases in environmental impact. Tenders and schemes that specify that renewables must be part of specific electrification programs without being based on detailed local assessments may inadvertently be eliminating the best solution from the choices available. Conversely, it is not necessary that the incremental generation for extending demand from the existing grid should be met from fossil fuels.

Costs

Costs vary significantly by application. The IEA[4] estimates costs of US$ 240 and US$ 270 per connection for South Africa and Sri Lanka respectively in 2001, but over US$ 1,000 per connection for rural Kenya and Uganda. These costs are not fixed: carefully designed programs, with constant cost analysis, can significantly reduce costs. Eskom's experience making 1.5 million new connections over a 5-year period in the 1990s in South Africa showed a reduction in costs of 50% per connection, from measures including optimizing line spacing between poles and developing low-cost component production and construction.

The IEA[5] has estimated that meeting the MDG1 target of reducing the proportion of the population on less than US$ 1/day by 50% by 2015 would require 560 million more people to gain access to some level of electricity, predominantly in sub-Saharan Afica and South Asia, than under business as usual projections. The extra investment would be some US$ 200 billion in the period to 2015, i.e., approximately US$ 400 per extra person given access to electricity. Assuming an average household size of 5 people, each connection would cost an estimated US$ 2,000. US$ 200 billion would represent a step change in investment. It is equivalent to approximately 10% of all developing country electricity investments projected to 2015.

Energy efficiency initiatives can support, and be supported by, schemes increasing access. Energy efficiency in low-income households can lead to economic and environmental benefits, but there are many barriers programs must overcome (e.g., initial cost, information and awareness of potential benefits, lack of access, multiple fuel patterns).

Financing

The economic benefits to those connected to electricity are high, and there is generally a net benefit to the country as a whole. These economic benefits include many factors (increases in productivity, better health and education, etc.) which do not appear in a financial balance sheet. Based on financial costs and benefits alone, electrification is not always an attractive investment. This has four major effects:

- All, or at least part, of the investments will be made by the State and the companies it owns. Private sector investment is generally focused in power generation rather than networks.
- There may be a need for subsidy, even if the program is being implemented by the electricity utility. Worldwide, state subsidies have always been required to realize the non-financial economic benefits of rural electrification. Ideally, subsidies should cover only part of the costs of connections and/or electricity consumed or be targeted to the poorest only using mechanisms outside electricity tariffs. The way a subsidy is applied is critical to how effective it is and its cost.
- Generally, extending urban networks is the most attractive financial investment, especially when concentrating on areas where productive industry can also be developed. However, if only these types of investments are made, income disparity between urban and rural areas will increase, as will pressure on the rural

population to move to urban areas. There is a need for electrification programs to develop urban and rural areas simultaneously.

- Foreign direct investment (FDI) is concentrated in a small number of relatively wealthy developing countries. Overseas development assistance (ODA) can provide the initial push in small, poor countries. Innovative financial structures (such as those employed in Tajikistan) may be required.

Residential customers are more expensive to supply than business, as they consume less electricity and require more infrastructure per unit of electricity supplied. The income from business customers allows the electricity supplier to act more independently (i.e., with less state support). This frees up finance, which can be used to further extend electricity networks to serve more customers. Experience has shown that without business development, electrification schemes have little impact on poverty alleviation and are generally financially unsustainable. Targeting small- and medium-sized enterprises (SMEs) are a key success factor, particularly in rural areas.

Financing electrification to the poor is further hampered by their inability to pay initial connection charges (the fixed costs of network development are high in relation to the quantity of electricity delivered), their often irregular and unpredictable income, and the bad precedent set by the often high rates of unauthorized electricity connections and non-payment of bills.

Financing is a complex problem, and is influenced by factors including the economic status of the community and the cost of connections. Electrification programs must take account of these factors and be modified and adapted to local conditions. The key concept is affordability: schemes must be designed such that communities can consistently make payments over long periods.

Good governance in the energy sector is critical to attracting infrastructure investment. Where utilities are not able to provide electricity, small-scale private sector providers (SPSPs) may offer niche electricity services, typically in rural or peri-urban areas. The World Bank[6] has estimated that 10 million customers in 32 countries already receive electricity in this way, and donors and other agencies are paying increasing attention to supporting SPSPs. They generally operate using either diesel generators with small networks (1-3 km) supplying electricity for about 4 hours per day or buy electricity from utilities and sell it on to the end consumer. Their local operations mean they are closer to the customers, their needs and their problems; they can also set tariffs without regard to centralized control.

IMPACTS

Environmental – Global

Key factors in the analysis of the impacts of electrification on emissions of greenhouse gas emissions, which each vary on a case-by-case basis, are:

- How the electricity is generated;
- Whether it replaces any other fuel and/or whether it creates new demand;
- The quantity of electricity generated.

In the short term, the most important factor is the level of electricity consumption in newly electrified regions, which is very low in comparison to the developed world. The total final consumption of electricity in Africa and South Asia in 2004 was 1,158 TWh, approximately 7.5% of world demand.[7] The level of electrification in these regions is approximately one-third of households. Trebling existing electricity demand would allow access to some level of electricity to all households and allow significant expansion in the supply of electricity to existing and new business, but would add only 15% to world electricity demand. Connecting households only would markedly reduce this increase.

In the longer term, we can expect poor households to significantly increase their consumption as their income increases.

The increase in greenhouse gas (GHG) emissions from this new demand would be of a similar order of magnitude to the increase in electricity demand. The impact could be reduced further by maximizing the share of renewables in new generation sources.

Environmental – Local

The provision of modern energy sources to poor households has a dramatic effect on air pollution, particularly within the home. The use of traditional fuels (biomass, dung, etc.) releases large quantities of particulates, which can cause severe respiratory impacts on those who spend time indoors (principally women and young children). Modern energy sources emit much lower quantities of pollutants and can also be used much more efficiently to provide a comparable service. Figures in Egypt[8] indicate that particulate emissions from biomass are in the range of 200-1,500 g/GJ of fuel burned, while those from kerosene are of the order of 2 g/GJ

fuel burned, i.e., at least 100 times lower. Moreover, kerosene use is much more efficient: 4-5 times as much biomass must be consumed to deliver the same service as from kerosene. Reducing biomass use is also beneficial to biodiversity (more biomass is left in situ, supporting animals and plants).

Electricity generally replaces the kerosene or candles used for lighting. As such, its impact on indoor and local air quality is limited: the replacement of cooking and heating fuels by modern energy sources (kerosene, LPG, etc.) has a much larger impact.

Electricity generation also causes local air pollution. This is clearly highly dependent on the fuel and technology used, with small diesel plants likely to give rise to significant levels of emissions, whereas renewable sources will give zero emissions, other than the potential for some side-effects such as possible leakage into groundwater from back-up batteries.

Insufficient electricity supply to business can also cause environmental problems if business then generates its own electricity using low-efficiency, polluting plants. This is the case in parts of China, where businesses subject to rationing resort to diesel generators. The emissions from this type of plant can be a significant contributor to local air pollution. They tend to pollute more than centralized generators and the pollution tends to have a larger impact since it is in or close to population centers.

Social/Community

Electrification is widely accepted to bring a wide range of social/community benefits. The key ones are perhaps improvements in the quality of life and health and increased business development.

Electrification programs need to be carefully designed in order to maintain social cohesiveness. An excessive focus on urban area electrification could lead to problems due to migration from rural areas.

FUTURE DIRECTION

South Africa's electrification program has made connections to over 2 million new households since its inception in 1994. The electrification rate of 66% is far in excess of the rate in any other sub-Saharan African nation. China supplies electricity to 99% of its population. Lessons drawn from the experience of these and other successful programs are:

- There is generally a weak business case for electrification without government support.
- Utilities must take the lead in delivering electrification schemes on the ground.
- Electrification programs must take account of market structure and institutions. In nationalized schemes, costs can be passed on to customers and it may be possible to cross-subsidize consumers with low demand and those in remote areas. In privatized systems with many market players, carefully designed incentives and regulations will be required.
- Both at the beginning of a program and on an ongoing basis, political commitment and determination are essential ingredients in undertaking a comprehensive electrification program.
- Infrastructure maintenance must be an integrated feature of electrification programs or there is a risk that schemes will become progressively inoperational.
- Program evaluation must account for quality of life improvements and socio-economic development as well as financial cost-effectiveness; these benefits are often realized over long periods.
- Optimal technology and operational choices can significantly reduce costs.
- Cost recovery must be strongly linked to user affordability, and will be higher if more reliable and efficient services are delivered.
- Linking electrification initiatives to other schemes can develop synergies. Schemes such as demand-side management/energy efficiency (e.g., subsidized efficient light bulb programs) can assist with the realization of benefits. Broader policies to promote investment, growth and productive employment (e.g., rural infrastructure development, training and education, micro-credit programs, land ownership reform) will increase incomes and make electricity more affordable. Schemes must be linked to affordability and carefully monitored over time.
- Electrification programs take a considerable amount of time to plan and implement. Increasing access to electricity happens slowly.
- Targeted research and investigation programs can play an important role in ensuring that electrification programs are optimized, customers' expectations are met and costs are reduced. Thus programs need to be continually adapted and modified in order to include lessons learned.
- Educating new consumers on the benefits and costs is a key factor in scheme success. For example, EDENOR's Buenos Aires electrification scheme included pre-payment meters. Their user-friendly metering systems show consumption levels using Light-Emitting Diodes (LEDs).

- Experience has shown that developing focused partnerships between major stakeholders is a key mechanism for achieving effective development programs. In Africa, these typically include government, the local and international private sector, state-owned enterprises, academic institutions and NGOs. Development needs to be combined with good business sense.
- Last but not least, electrification should be seen as one element in a broader energy and development strategy. It generally helps to reduce local pollution, but often the cheapest reductions in local impacts come from non-electricity measures such as substituting biomass in heating and cooking with fuels such as kerosene and LPG.

REFERENCES AND NOTES

1 International Energy Agency. *World Energy Outlook 2002.* 2002.

2 All figures under the *Statistics* section come from: International Energy Agency. *World Energy Outlook 2004.* 2004.

3 The definition of "Access to Electricity" varies. Here it applies to those who have authorized access in their homes, from either centralized or distributed electricity networks.

4 International Energy Agency. *World Energy Outlook 2004.* 2004.

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6 Kariuki, Mukami, Jordan Schwartz, World Bank Policy Research Working Paper 372, "Small-Scale Private Service Providers of Water Supply and Electricity, A Review of Incidence, Structure, Pricing and 6 Operating Characteristics". World Bank, Energy and Water Department. October 2005.

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8 ERM for the World Bank. *Egypt: Energy Environment Review.* 2002.

About the WBCSD

The World Business Council for Sustainable Development (WBCSD) brings together some 180 international companies in a shared commitment to sustainable development through economic growth, ecological balance and social progress. Our members are drawn from more than 30 countries and 20 major industrial sectors. We also benefit from a global network of 50+ national and regional business councils and partner organizations.

Our **mission** is to provide business leadership as a catalyst for change toward sustainable development, and to support the business license to operate, innovate and grow in a world increasingly shaped by sustainable development issues.

Our **objectives** include:

- **Business Leadership** – to be a leading business advocate on sustainable development;
- **Policy Development** – to help develop policies that create framework conditions for the business contribution to sustainable development;
- **The Business Case** – to develop and promote the business case for sustainable development;
- **Best Practice** – to demonstrate the business contribution to sustainable development and share best practices among members;
- **Global Outreach** – contribute to a sustainable future for developing nations and nations in transition.

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