



International
Energy Agency

COMPARATIVE STUDY ON RURAL ELECTRIFICATION POLICIES IN EMERGING ECONOMIES

Keys to successful policies

INFORMATION PAPER

ALEXANDRA NIEZ



2010 MARCH

INTERNATIONAL ENERGY AGENCY

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This paper was drafted by the IEA Energy Technology Policy Division. It reflects the views of the IEA Secretariat and may not necessarily reflect the views of the individual IEA member countries. For further information on this document, please contact Stefanie Held at: stefanie.held@iea.org

Acknowledgements

This Information Paper is the first IEA study focusing exclusively on rural electrification policies in major emerging economies. Its aim is to provide keys to successful rural electrification policies. Its conclusions and recommendations are based on an analysis of the rural electrification programmes of Brazil, China, India and South Africa.

The International Energy Agency and the author wish to thank Antonio Pflüger, former Head of the IEA Energy Technology and Collaboration Division for suggesting the theme of this paper, for finding funding, and for all the very useful comments and ideas he provided during the initial phase. Many thanks also to Peter Taylor, Head of the Energy Technology Policy Division and Stefanie Held, Head of the Technology Network Unit, for their supervision.

Many thanks to Dagmar Graczyk, Julie Jiang, Ghislaine Kieffer, Teresa Malyshev, Jonathan Sinton from the IEA as well as to Celia Salama Andrade (PPE/COPPE/UFRJ), Dirk Assman (GTZ), Jens Burgtorf (GTZ), Helene Rask Grøn (Baobab Consult CC.), Frank Haugwitz (EU-China EEP), Emilio Lèbre La Rovere (CGEE), Haibo Meng (IEEP), Kadri Nassiep (SANERI), Martin Obermaier (PPE/COPPE/UFRJ), Marcelo Khaled Poppe (PPE/COPPE/UFRJ), R.K. Sachdev, Daniel Werner (GTZ), the Brazilian Ministry of Mines and Energy and the South African Department of Energy Electrification Chief Directorate for their contributions, comments and provision of country-specific data. My appreciation to the IEA Implementing Agreements for their contributions on technology-specific data, and specifically Gouri Bhuyan (OES IA), Adam Brown (Bioenergy IA), Ana Estanqueiro (Wind IA), Bernard McNelis (PVPS IA), Niels Nielsen (Hydropower IA) and Mary-Rose Valladeres (Hydrogen IA). Many thanks also to Christophe Dossarps (UNDP Consultant), Martina Otto (UNEP) and Anjali Shanker (IED) for their comments and review of this paper.

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Executive summary

Brazil, China, India and South Africa have each worked to improve access to electricity services. While many of the challenges faced by these countries are similar, the means of addressing them varied in their application and effectiveness. On the basis of our analysis of these four country profiles, we have determined the prerequisites to successful rural electrification policies.

1: Preconditions to successful rural electrification policies

- Sound statistical data on populations' geographical distribution and a clear description of the electrification situation are essential if governments are to avoid the risk of overlooking remote population groups and to facilitate the choice of end-use.
- Sustained government support and long-term funding will guarantee a more effective implementation of electrification objectives, and the elimination of any misuse of electrification funds in favour of other objectives.
- Dedicated institutional structures and independence from political agendas ensure that funds are “ring-fenced”, efforts are durable and electrification objectives are not interfered with according to politicians' personal agendas.
- The establishment of a strong market infrastructure to attract private investors ensures the wider use of stand-alone systems in remote areas.
- Related policies and/or regulations including energy efficiency policies should be implemented alongside the electrification process to sustain long-term economic development.
- Connection costs should be eliminated or spread over time so as to minimise any upfront hindrances to being connected, and electricity tariffs should be affordable but not necessarily subsidised.
- Effective metering, billing and payment recovery ensure the long-term viability of the electricity supplier and therefore of the electrification process as a whole.
- Full involvement of the rural communities in the electrification efforts throughout the decision-making process increases their sense of ownership and brings support to utilities' efforts to encourage customers to use electricity wisely once they are connected.

2: Stand-alone systems: conditions for successful rural electrification efforts

- Locally-produced and resource-specific technologies for electrification will reduce the need to import systems and facilitate their use in any given region.
- Good management and maintenance of the systems require adequate training, assistance services and customer supply chains for their long-term use.
- Sufficient long-term funding ensures long-term system maintenance.
- Banning the idea that stand-alone systems provide “second-class” electricity gives communities a sense of ownership of the system.

3: Grid extension: conditions for successful rural electrification efforts

- Reduction of transmission and distribution losses keeps costs of electrification under control.
- Reduction of losses due to electricity theft ensures suppliers' longer-term viability.
- The use of low-cost technologies keeps costs of electrification under control.

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4: Three rural electrification boosters

- Social fairness can be one of the initial driving motivators in the first stages of electrification. Indeed, economic development will follow sooner or later even when productive end-uses are not the prime objective to electrification.
- Minimising trial and error through benchmarking and exchanges with other countries accelerate the electrification process.
- Co-operation in the framework of IEA Implementing Agreements for exchanges on technologies and support in policy formulation will spur the electrification process and facilitate long-term collaboration with other countries on other policy and technology issues of interest.

Introduction

Since the G8 Gleneagles Summit in 2005, the International Energy Agency's (IEA) Networks of Expertise in Energy Technology (NEET) Initiative¹ has sought to encourage further involvement of major emerging economies in the IEA Technology Network comprising international energy technology and R&D collaborative programmes. Missions and workshops when feasible have been organised in the so-called "Plus-Five" countries, namely Brazil, China, India, Mexico and South Africa. These outreach efforts have been geared towards identifying areas of mutually desirable and potential future collaboration between experts of these major emerging economies and the IEA Technology Network including the Committee on Energy Research and Technology (CERT), Working Parties (WP) and Implementing Agreements (IA).²

Rural electrification has been singled out as a potential field for international collaborative activities within the IEA framework. Policy makers, industries and R&D institutions in the targeted economies have all expressed interest in discussing with one another and with international experts, in exchanging their experiences, lessons learned and continuing challenges in their efforts to bring energy services to the rural world. In response to this interest, the IEA has begun exploring its role as facilitator of international exchanges on energy technologies and policies for rural electrification in developing economies.

In May 2008, the IEA hosted a workshop on "Sustainable Rural Energisation in Major Emerging Economies", in collaboration with the Gesellschaft für Technische Zusammenarbeit (GTZ) and with the support of the United Nations Environment Programme (UNEP) and the Renewable Energy Policy Network for the 21st Century (REN21). The goal of this workshop was to explore opportunities for extending IEA's collaborative activities to better respond to the major emerging economies' interest in international collaboration on rural energisation.³ Delegates from eleven emerging economies, namely Bangladesh, Brazil, Chile, China, Egypt, India, Indonesia, Mexico, Morocco, Pakistan and South Africa, met representatives from nine IEA Implementing Agreement (IA) programmes and from interested government and international bodies. This was an opportunity for IAs to display their collaborative activities and discuss with the country representatives on how to join forces in carrying forward existing efforts. Specific goals were also to establish to what degree the emerging economies are committed to such collaboration and to identify the preferred vehicle. The key messages emerging from the workshop highlighted the importance of a constructive dialogue and a "made-to-measure", non-prescriptive approach. Participants also noted the need to have the IEA as a focal point for information exchanges not only between the IEA countries and emerging economies, but also among the latter. They noted that rural energy decision makers required support in adapting policies to local conditions and that assistance was needed in technology transfer and capacity building, both technical and policy-related. They encouraged further work on policy benchmarking and invited the IEA to undertake a comparative analysis of the effectiveness and efficiency of national and regional policies to accelerate rural energisation.

¹ For more information on the IEA's NEET Initiative, refer to <http://www.iea.org/neet>

² For more information on the Committee on Energy Research and Technology (CERT), Working Parties (WP) and Implementing Agreements (IA), refer to the 2007 *Energy Technologies and the Cutting Edge* IEA study book also available online at http://www.iea.org/textbase/nppdf/free/2007/Cutting_Edge_2007_WEB.pdf

³ The proceedings and summary paper of this event can be found under http://www.iea.org/textbase/work/workshopdetail.asp?WS_ID=379

This paper directly stems from the conclusions of this workshop. It describes the rural electrification policies adopted by the four major emerging economies, with a view to analysing the keys to the successful implementation of such policies.⁴

Rural electrification: main challenges and issues

Roughly 22% of the world's population still does not have access to electricity. In 2008, this represented 1.5 billion people, most of whom lived in remote areas often difficult to access and therefore to connect to national or regional grids. The International Energy Agency estimates that roughly 85% of the people without electricity live in rural areas in developing countries, mostly in peri-urban or remote rural areas (IEA, 2009b). Today, most of these people are found in sub-Saharan Africa and South Asia. The IEA predicts that in 2030, if no new policy to alleviate energy poverty is introduced, 1.3 billion people (some 16% of the total world population) will still be denied electricity most of whom in South Asia and Africa (IEA, 2009b).

Not all electrification policies target poor rural households. Some also target a mix of farms, big villages and small towns all of which call for different technologies. In fact, rural electrification policies are shaped according to the various energy needs, resources and target groups. Electrifying the suburb of a major Indian city obviously poses problems that are different from those of a remote village in China. As problems are far greater in rural areas than in urban settings (Barnes, 2007) we will focus our attention on electrification policies in favour of the world's rural poor.

General challenges faced by rural communities

Rural electrification is defined here as the process by which access to electricity is provided to households or villages located in the isolated or remote areas of a country. Remote or rural regions lacking electricity supply are often characterised by well identified challenges. They may lie at a reasonable distance from national or regional electricity grids (remote villages in the Amazon), may be difficult to access (far from urban centres with a difficult terrain such as large rivers or jungles), or may suffer harsh climatic conditions that render electrification through grid extension a perilous task. Rural communities are also often highly dispersed with a low population density and characterised by a low level of education, low load density generally concentrated at evening peak hours, and low revenues. Adding to these challenges, the rural poor without access to electricity either spend relatively large amounts of their scarce financial resources on energy, or a disproportionate amount of time collecting firewood.

In light of these challenges, electricity provision to the world's rural poor calls for a committed and long-term action plan. The benefits that electricity access brings to households and communities are justified not only on social and economic grounds but also on grounds of equity objectives.

Social benefits of electrification

At the household level, electricity is mainly used for powering light bulbs, fans, television sets, computers and phones (when available). For over 30 years the World Bank and other organisations have studied the social benefits of electricity access and have noted that these benefits usually derive from the longer days that powered light bulbs offer to the household. In addition, access to information, communication and health care is facilitated by the powering of computers and

⁴ As a first step, rural electrification and not energisation is the focus of the paper.

phones. When electricity is used for powering home appliances, household chores tend to become less tedious; when it is used for lighting, the relative brightness of the light bulb as opposed to candle light allows children to read or study in the later hours of the day, bringing obvious education and leisure benefits (Barnes, 2007). Women and children benefit directly from these improvements, but table or ceiling fans and television sets offer comfort during evening leisure time, increasing the general welfare of all members of the household.

Economic benefits of electrification

Besides the social benefits, decision makers tend to give more importance to the economic impact of access to electricity as an income-generating process. Electricity use is expected to lead to more productive processes; the growth of businesses or farms using electricity will then increase demand for electricity, leading to a virtuous growth cycle profitable to both electricity providers and rural communities. Such economic growth is obviously an important achievement of any rural electrification programme. Some experts (Barnes, 2007), however, warn that the necessary conditions for such economic growth lie in the parallel or complementary development programmes for the newly electrified communities. While electricity is indeed an important input to rural businesses, farms or other small rural structures, adequate local conditions such as organised rural markets and sufficient credit are necessary for such businesses to grow. Lack of such complementary development programmes in these regions may hinder their economic growth.

Technologies commonly used in rural electrification policies

Socially, ethically and economically beneficial, the electrification of rural or remote areas is usually high on the agenda of the leaders of major emerging economies, but the main problem to overcome is the choice of the technology.

The choice of a specific energy technology for rural electrification naturally depends on the targeted country and on whether it is a whole region, community, business, farm or household that is to benefit from the process. But this is not the only concern. Issues of customer and load density, relative distance to the national or regional grid, landscape, availability of natural resources such as wind, sun, water, forests, economic and financial aspects, availability and maturity of any chosen technology, all these factors influence the decision maker in his choice of the technology or technology mix.

The pool of potential energy technologies for rural electrification programmes is quite large and each technology naturally varies in its generation technique, its costs, and in the quality of the service it delivers. Depending in part on the degree of urbanisation of the targeted population, energy technologies used in electrification programmes generally involve national or regional grid extension, diesel generators, liquefied petroleum gas (LPG), disposable batteries, kerosene lamps, renewable energies (including photovoltaic systems, wind energy, hydropower, and new wave energy and hydrogen) or hybrid systems.

National or regional grid extension

When aiming to electrify a rural community, the first question is its distance from a grid. If grid extension appears to be relatively easy (the region is near to the grid, flat landscape), is cost-competitive with respect to other local autogenerators, and if the region's load density is considered sufficient, then grid extension will usually be a preferred option. In India for instance,

the first choice for a majority of the villages has been through grid extension. But many of the dispersed rural communities did not meet all these criteria at once. Grid extension was then the final phase of a sequential rural electrification process and other local electrification technologies were chosen in the meantime. In fact, once demand was built over the years by means of auto-generation, and it became economically feasible to connect to the central grid, grid extension was chosen as a final step. Recently, however, mentalities have been changing and governments as well as rural communities are beginning to see stand-alone systems as long-term and reliable options for power generation, rendering grid extension less of a mandatory long-term means of electrification.

Conventional systems

Diesel generators, LPG, disposable batteries, paraffin (or kerosene) and biomass technologies have all been conventional means for dispersed populations to have access to electricity services. Today however, sustainability considerations are encouraging developing economies to focus their efforts, where possible, in deploying cleaner energy technologies such as renewable and more sustainable bioenergy applications. But diesel generators remain an attractive technology in rural electrification, mainly used in hybrid systems.

Renewable energy systems

Often considered the optimal means of bringing electricity to rural areas that cannot be connected to the grid, renewable energies offer notable environmental advantages over conventional fossil fuel technologies. The most widely used renewable energy technologies for rural electrification are described below.

Photovoltaic (PV) power systems already provide electricity in developing countries to an estimated minimum of 500 000 to 1 million rural households without access to the grid (International Finance Corporation, 2007). Particularly attractive for countries with ample sunlight and whose rural electricity grid is poorly developed, PV systems can provide electricity to relatively dispersed populations but also to groups of houses or entire villages. The most common systems used in rural areas in developing countries are solar home systems (SHS), which have the potential to power light bulbs and small appliances such as televisions, radios or fans. Generally the capacity of the units used in rural households ranges from 30 to 100 peak watts, but their size varies (Erickson & Chapman, 1995). However, because of the systems' limited capacity, mechanisms are often needed to prevent excessive consumption by users. Currently, there is a move towards solar-diesel hybrid-powered mini-grids.

Photo 1: School in South Africa powered by a photovoltaic system



Source: Courtesy of Bernard Mc Nelis, IEA PVPS.

Wind energy has a very high potential for rural electrification thanks to its intrinsic characteristics. Wind energy does not necessitate long-term centralised planning for its development as it is fast and simple to install. In most rural settings, when several smaller wind turbines are installed rather than a very large one, the grid can easily absorb wind generation. Successful examples of rural electrification based on wind power are the Atlantic islands of Canary, Azores and Cape Verde, where the high wind resource turns this renewable energy into among the most cost-effective power plants to install and operate.

Small hydropower projects already provide electricity to millions of people throughout the world, with the largest deployment being in China. These power plants can vary in size from less than 500 kW to about 10 MW and most are developed at the community level or for small industry. In addition to electricity, they also provide mechanical energy for small businesses, drinking water and irrigation through canals or pumps. While some small hydro plants use imported technology, there is an increased reliance on local manufacture. This provides employment opportunities over and above electricity to the communities. There remains a huge potential to increase the role of small hydro in supplying electricity to small, rural populations. Mini-hydropower plants are however often criticised for their inability to provide sufficient power to meet peak demand or for their excess capacity during off-peak periods. In order to limit the financial burden due to such tensions, consumers often have to either constrain their use of electricity during peak hours, or transfer their demand on to off-peak hours.

Bioenergy already provides the main source of energy for heating and cooking for many millions of people in rural communities. Where adequate sources of biomass raw materials are available – for example from crop or forest residues – then these can also be used to generate electricity. This can be done in conjunction with larger plants which also use energy to process crops (for example the use of bagasse in sugar cane production). Alternatively smaller-scale systems based on biomass combustion or small-scale gasification can be used to generate electricity for local use. Moreover, biofuels such as non-edible straight vegetable oils (SVOs) produced from plants like *Jatropha*, can be directly used for transport applications and decentralised power generation or converted to biodiesel and blended with petro-diesel.

Photo 2: Transporting fuel wood in Brazil



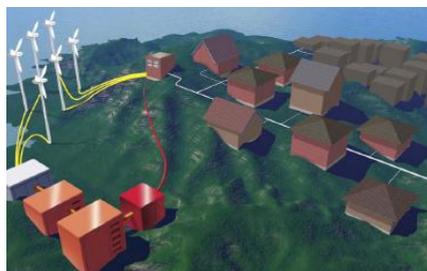
Source: Courtesy J. Tustin, IEA Bioenergy IA.

Ocean energy could play a significant role in enabling sustainable energisation of rural coastal and island regions of the developing countries by generating electricity, producing drinking water through desalination, or food through aquaculture, and cooling. This would however require appropriate policy instruments and real political will. Currently, project development activities are at an early stage in China, India, and Indonesia for providing electricity to rural households by harnessing energy from ocean waves and tidal currents. During 2007, Ponte di Archimede International S.p.A. entered into three joint ventures with the People's Republic of China, Indonesia

and the Philippines to install tidal current-based generation in remote villages. The Research and Technology Ministries in the respective countries participated actively in the formation of these ventures. The installation of tidal current projects of a similar size in remote villages is currently being planned in China and the Philippines. A 2 MW tidal current plant is being considered by India to bring electricity to a remote area near Sunderban in West Bengal. A low-temperature ocean thermal desalination (LTTD) plant has been operating since 2005 at Kavaratti in Lakshadweep islands in western India and that provides 100 m³ per day of drinking water to a local community. There are also significant opportunities to utilise wave and tidal current energy for sustainable energisation of remote coastal areas in Mexico, Brazil and South Africa and activities are already under way in these countries.

Hydrogen may well play a key role in distributed energy generation for which rural areas are prime candidates. Hydrogen "generators" (small-scale portable power devices such as reformers and fuel cells) may be substituted for the common diesel generators that are widely used. Hydrogen can also be used as fuel to power backup devices (larger fuel cells) and to provide combined heat and power (CHP). However, because it is innovative and new (at the demonstration and early market introduction stages) the typical household in rural settings would not be appropriate for hydrogen use. There are, however, some 400 stationary hydrogen demonstrations in the world. Unlike the photovoltaic industry or solar water-heating and cooling and other alternative technology industries which have started from scratch, hydrogen is already a large business with an infrastructure that can kick-start production, storage, delivery or energy applications as the deployment process continues. Hydrogen technologies may in the future bring innovation to the current supply of rural electrification technologies.

Photo 3: Prince Edward Island (PEI) Wind-Hydrogen Village Project CanmetENERGY



Source: Natural Resources Canada.

Hybrid systems

Hybrid systems are basically a combination of two or more different but complementary energy supply systems located on the same site. The advantage of hybrid systems is their ability to avoid fluctuations in the system's energy supply, which is the main disadvantage of stand-alone renewable energy technologies such as wind and PV. A hybrid system will provide a relatively constant delivery of energy even when one of the supply devices of the system is unable to generate power (lack of wind in the case of a windmill or of sunlight in the case of a PV). Often, hybrid systems will be a combination of different renewable energy technologies, sometimes coupled with diesel gen-sets. Typical hybrid systems are photovoltaic/wind systems, wind/diesel systems, wind/photovoltaic/micro hydropower systems, or wind/small hydropower and so forth.

Typically, apart from local ambient conditions, economical and financial issues, the choice of which energy technology or mix of technologies to use for rural electrification will depend on whether the energy produced will be used for lighting or cooling purposes in a single household, or for productive processes (irrigation pumping, water supplies, crop processing, refrigeration, etc.) of businesses, agro-industries, small shops, and so on.

A focus on government policies for rural electrification

Most developing countries include rural electrification policies in their socio-political development efforts. The existing economic inequalities between urban and rural populations and these countries' social equity objectives tend to be the main drivers to providing electricity access to isolated populations. By doing this, governments of developing countries seek to improve the living standards of their rural populations and help them economically in order to help level out rural/urban disparities. Moreover, substantial upfront costs and long-term financial investments are required to accelerate the pace of rural electrification. Such financial security depends on government support.

Efficient implementation of rural electrification programmes often needs regulations and market reforms, including market incentives through increased competition for private involvement and above all government involvement. Moreover, technical standards and norms can lead to an oversizing or costly infrastructure set-up for the electrification of rural households or villages, which will increase connection costs and the price of electricity. A reassessment of these standards and norms at the government level may prove necessary to alleviate the unnecessary additional financial burden from the electrification effort in rural areas.

The following chapters will analyse countries where government-led rural electrification programmes have been implemented. These countries are Brazil, China, India and South Africa. Through benchmarking current achievements with previously set targets, we will infer the main challenges faced by implementing bodies and how these have been addressed. The analysis of the country chapters⁵ bring forth the important issues that need to be considered and addressed for the successful implementation of a rural electrification policy.

⁵ These four country chapters display the electrification efforts of Brazil, China, India and South Africa which have achieved more than 65% electrification rate, through huge and running systems, albeit with difficulties. These countries have been able to release substantive funds to finance rural electrification, and have relied on companies which had sufficient know-how and expertise to achieve the plans. The situation is different in sub-Saharan Africa where electrification is closer to 10% (with some exceptions such as Ghana or Cameroon). Country reviews on some Sub-Saharan African or South Asian countries would bring greater insights into the additional difficulties faced by countries with lower national capacity.

1 Brazil

Since the 1988 Constitution, the federal government of Brazil has been assuming full responsibility for the distribution of electricity as an essential public service. As a consequence of strong political will and the release of sufficient funds, in 2009 Brazil reached an overall electrification rate of 97.8%. This rate was 99.5% in urban areas and 88 % in rural areas (IEA, 2009b). This has been achieved largely through grid extension. Stand-alone systems may be more widely used in the future. The country's energy sector, electrification efforts and remaining challenges are described below.

1.1 Introduction and country description

Brazil is the fifth-largest country in the world, covering an area of 8.5 million km², equal to about half of the South American continent. It is limited to its east and north by the Atlantic Ocean, its inland frontiers border with all Southern American countries except for Chile and Ecuador (Wikipedia, 2009a). Brazil belongs to the so-called megadiverse countries, a group that encompasses about 70% of the planet's biodiversity (WCMC, 1992). Particularly notable are its large tropical Amazon and Atlantic coast rainforests as well as the large peatlands (the *Pantanal*) of the midwest. Brazil also extends over semi-arid areas in the north-east (the *Sertão*) and vast plains in the south. It has one of the world's most extensive river systems, including the Amazon and São Francisco rivers. Most of the country lies between 200 and 800 metres in elevation. The weather is mainly tropical (Wikipedia, 2009a).

Economic data

Over the past years, Brazil has enjoyed a period of stable economic growth with significant social and environmental advances. While the country did not escape the global economic downturn in 2008, Brazil has been able to cope with the crisis by relying on sound macroeconomic policies, as well as by expanding its social security net, infrastructure and housing investments (World Bank, 2009a). Real GDP in purchasing power parity (PPP) growth has averaged 4.5% over the 2000-2007 period (OECD, 2009) before growth prospects dropped to 0.5% in 2009 because of the crisis (World Bank, 2009a). GDP/PPP attained USD 1 833 billion in 2007 (OECD, 2009) but is highly concentrated in a few regions: the three major economic states of the south-east (São Paulo, Rio de Janeiro, and Minas Gerais) account for over half (54.4%) of GDP (IBGE, 2007a).⁶ Brazil's main foreign trade partners include the European Union, the United States, Mercosur members, as well as China.

Population and economic profile

In 2000 Brazil undertook a census which reported a population close to 170 million inhabitants (IBGE, 2002). By 2007 this number had increased to nearly 190 million people, an increase of about 20 million in only eight years. While the urban population has been constantly rising throughout these years (from 142 million in 2001 to 160 million in 2006), the rural population has remained relatively constant at 30 million inhabitants (IBGE, 2007b).⁷ Estimations of population density show

⁶ Brazilian reals (BRL) have been converted in USD using the 11 September 2009 exchange rate between the two currencies. 1 USD is equal to BRL 1.83035 and 1 BRL to USD 0.54790 (source: <http://www.oanda.com>).

⁷ According to IBGE (2007b) *urban* includes all municipal and district capitals as well as isolated urban-like areas, while *rural* includes everything outside these perimeters.

much lower indices in rural areas (6.3 inhabitants/km²)⁸ than in urban areas (between 33.1 and 36.8 inhabitants/km²).⁹ Of the total economically active population, the largest share works in services (59.6%), followed by industry (28.0%) and agriculture (6.7%) (OECD, 2009).

There is no officially defined poverty line in Brazil; however, the concept of minimum wage is often used in analyses. Accordingly, Silveira and Fernandes (2007) find that the number of indigent people decreased from 12.4% in 2001 to about 7.6% in 2005, and the number of poor people from 28.7% to 20.8%.¹⁰ Brazil has thus already met the Millennium Development Goal of reducing substantially the number of people living in poverty (World Bank, 2009a). Though poverty has been alleviated in the past few years, extreme poverty still affects a large population, particularly in the country's rural parts of the north-east (Presidency of the Republic, 2007; Silveira *et al.*, 2007). Average rural per-capita income is substantially lower than in urban areas: BRL 312 (USD 171) against BRL 689 (USD 377.5) (IBGE, 2007b). Furthermore, rural regions also display less access to public services, such as lack of clean water, sanitation, health services, education, and particularly electricity supply, further highlighting the gravity of the rural poverty problem (Rosa *et al.*, 2006).

Energy data

Brazil's energy matrix is based on a comparatively high use of renewable energy, including large-scale hydropower for electricity generation and biofuels for transport (IEA, 2006; EPE, 2008). In 2007, the country's overall energy consumption reached 216 million tonnes of oil equivalent (Mtoe), with demand driven mainly by petroleum derivatives (41.4%, particularly diesel oil and gasoline), electricity (16.4%), and sugar cane bagasse (12.4%) (EPE, 2008). Owing to dramatically increased production of petroleum, domestic dependence on oil imports has decreased sharply over the past years (EPE, 2008; OECD, 2009). Brazil still imports considerable amounts of coal and, to a lesser degree, electricity, the latter being obtained in particular from Argentina (EPE, 2008; Costa *et al.*, 2008).

Electricity generation

Overall domestic electricity supply increased by 5% between 2006 and 2007, reaching a total of 483.4 TWh (EPE, 2008). This makes Brazil the largest electricity market in South America (IEA, 2009c). Large hydroelectricity supplies 72.6% of all electricity, followed by thermoelectricity generation (14.7%) (EPE, 2008). Installed electricity generating capacity is around 100 GW (EPE, 2008). It can be assumed that electricity consumption in rural areas is considerably lower than in metropolitan areas. This holds particularly for the household sector where poverty levels are higher and overall population is low.

Because of the strong reliance on large hydropower dams for electricity generation, most electric energy today (98%) is supplied by the large regionally integrated grid transmission system (also known as the *Sistema Interligado Nacional*, SIN) (ESMAP, 2005). Only in the remote areas of the Amazon, which cover about 45% of the Brazilian territory but with only 3% of the national population, grid electrification has been in part replaced by decentralised electricity supply alternatives: mainly small diesel plants supply isolated villages and towns at a total nominal capacity of only about 3 GW (Andrade, 2009a). The cost of electricity generation in these areas is high and reaches USD 200/MWh (ESMAP, 2005). This is mainly due to the high costs of fuel and

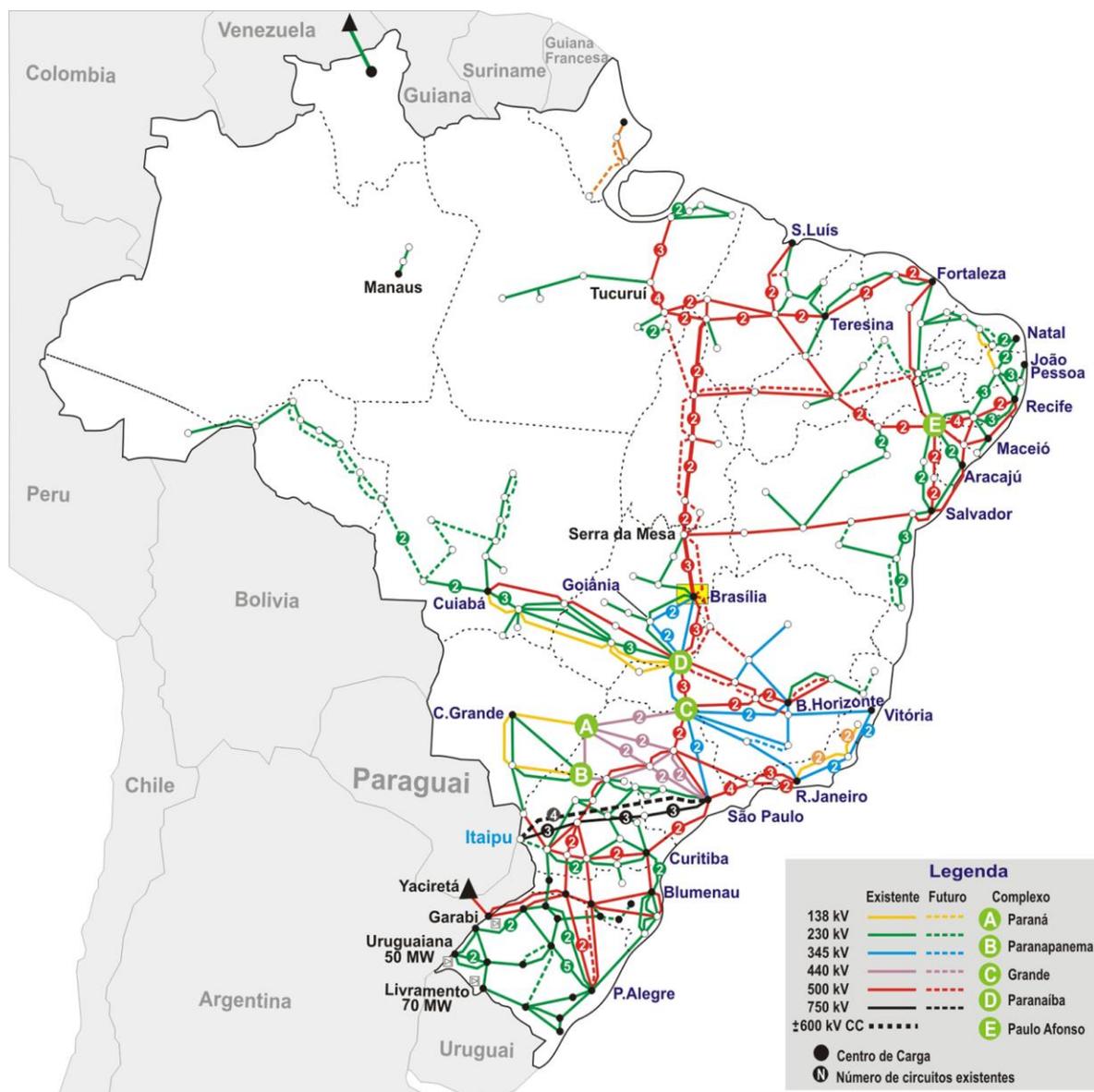
⁸ Calculations based on Girardi (2008).

⁹ Calculations based on Girardi (2008).

¹⁰ The poor include those with less than 1/2 a minimum wage per month and the indigent those with less than 1/4 of a minimum wage per month (Silveira and Fernandes, 2007). For comparison, in September 2007 the minimum wage was at BRL 380 (IBGE, 2007a).

transportation (Goldemberg *et al.*, 2004). The service is also weak, often because of the inefficient functioning of old motors.

Figure 1: Sistema Interligado Nacional (SIN, or National Interconnected System)



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Source: ONS (2009).

Institutions involved in the power sector

Brazil's electricity sector today is fully deregulated. Generators (mostly large government-controlled companies, but also several private power producers) sell their electricity to distributors via auctions. Electricity distribution is mainly operated by the private sector, whereas transmission is both publicly and privately owned. The provision of electricity services relies on government concessions, and the country is fully covered by either private or state-owned concession areas.

Smaller regions are sometimes covered by authorised rural electrification cooperatives (ESMAP, 2005). Institutionally, the Ministry of Mines and Energy (MME) oversees the whole power sector and is responsible for policy setting. The Brazilian Electricity Regulatory Agency (ANEEL), operating under the jurisdiction of the MME, regulates and controls the generation, transmission and distribution of power in compliance with current legislation. Eletrobrás is a federally-owned holding company for electricity assets, controlling a large part of electric power generation and transmission systems mainly through six subsidiary companies, as well as some distribution capacity in the Amazon area. The *Empresa de Pesquisa Energética* (EPE, or Energy Research Company) is responsible for the development of integrated long-term planning of Brazil's power sector, thus supporting MME's national energy policy and long-term planning.

Urban-rural electricity access

Access to electricity in rural areas has widened strongly throughout the past years. By 2007, 55.35 million out of a total 56.34 million permanent residences were connected to electric energy. In 2009, the overall Brazilian electrification rate reached 97.8%. The rate is 99.5% in urban areas and 88 % in rural areas, putting Brazil among the group of Latin American countries with near-universal electricity access (IEA, 2009b). The Ministry of Mines and Energy expects that electricity will be available in every single Brazilian household by 2010. A few years ago, only 73% of the rural population had access to electricity and 12 million people in 2.5 million households were still without electricity (ESMAP, 2005).

1.2 Institutional structures for rural electrification

The Brazilian Constitution of 1988 recognises the distribution of electricity as an essential public service, for which the federal government is to assume full responsibility, either directly or through designated concessions or permits (Goldemberg *et al.*, 2004).¹¹ Up to the 1990s, rural electrification policies were often implemented at the state level, using state treasury resources, and having the programmes implemented by concessionaires controlled by state governments (ESMAP, 2005; Instituto Acende Brasil, 2007a). Besides these activities, a number of international donors as well as non-governmental organisations supported or implemented several non-sectoral and decentralised electrification projects in Brazil, with institutional set-ups and responsibilities varying considerably between the different programmes (see Goldemberg *et al.*, 2004; ESMAP, 2005; Zerriffi, 2007).

1.2.1 Major electrification programmes

Two large federal-led rural electrification programmes – PRODEEM (*Programa de Desenvolvimento Energético de Estados e de Municípios*, or Energy Development Programme of States and Municipalities) and *Luz no Campo* (LnC, Light in the Countryside) – were established in 1994 and 2000 respectively, however without a clear target for reaching universal access in rural areas. Because no specialised federal rural electrification agency existed, PRODEEM and LnC were co-ordinated by different actors: LnC by Eletrobrás under coordination of the MME, and PRODEEM directly by the MME. Both programmes also drew funding from different sources, the National Treasury Funds in the case of PRODEEM, and *Reserva Global de Reversão* (Global Reversion Reserve, or RGR) loans for utilities in the case of LnC (Goldemberg *et al.*, 2004; ESMAP, 2005). The

¹¹ Service providers are mainly concessionaires and permissionaires (permit-holders) authorised by ANEEL. Generally speaking, permit-holders are independent operators that work inside a concession area. Rural electrification co-operatives can become permit-holders if they provide a public service (ESMAP, 2005).

RGR was implemented as early as 1971 and has been managed by Eletrobrás. About one-fourth of the available RGR resources are set aside by law for low-income consumers in rural areas (ESMAP, 2005). There were no other significant federal rural electrification funds.

In 2003 the current rural electrification programme, *Luz para Todos* (Light for All, or LpT), which is to give universal access in the country's rural areas by 2010, was formalised and implemented. The programme is based on the obligation for service providers to universalise rural electricity access (as set by the Brazilian Constitution), on substantial federal and state resources for the service providers, and on low tariffs for low-income and rural consumers (Zerri, 2007; Poppe, 2009).

1.2.2 Institutional structure – implementation and funding

On 11 November 2003, LpT was inaugurated. LpT's original aim was universal access to electricity in all rural areas of Brazil by 2008, keeping in mind the five-year deadline defended by ANEEL. In total numbers, LpT was to provide two million rural connections (MME, 2003; Eletrobrás and MME, 2009) for free to yet unattended consumers, where each household would also receive an "internal kit" containing several power plugs, lamps, and other necessary material (Eletrobrás and MME, 2009). Because of the surge of new demands for rural electrification not identified when the programme started and for other reasons, the original LpT deadline was postponed to 2010 (Eletrobrás and MME, 2009).

With LpT, a new institutional structure for rural electrification emerged, in which the Regulatory Agency ANEEL (established during the electricity sector restructuring process during the 1990s) and Eletrobrás play pivotal roles. ANEEL is responsible for the authorisation of concessionaires and other service providers (which generally occurs through bidding processes among interested actors) (ESMAP, 2005). ANEEL also sets and verifies the annual electrification targets for LpT. Eletrobrás, on the other hand, holds the operational secretariat of the programme. This includes carrying out the technical and financial analyses of the connections to be installed by the service providers, the allocation of funds to these actors, and the supervision of the installations. As with LnC, the MME co-ordinates the development of the LpT programme and sets its general policies. Several decision and advisory councils at federal and state levels support the institutional structure for rural electrification, dealing with various issues such as the promotion of productive uses of energy in newly connected municipalities or the setting-up of priority lists for rural electrification operations. These councils generally involve a great variety of stakeholders which, depending on the level of the council (federal or state), may include representatives from the MME, other ministries, Eletrobrás, ANEEL, local municipalities, unions, and the service providers (Eletrobrás, 2008; Eletrobrás and MME, 2009).¹²

State governments support the federal government's LpT universalisation strategy by providing part of the funds – in the form of grants to the service providers – to finance operations. These contributions are on average in the order of 10% of total LpT investments (Instituto Acende Brasil, 2007a). The main funding sources, however, still come from the federal government: through RGR grants and loans (at low interest rates) and grants from the newly implemented *Conta de Desenvolvimento Energético* (Energy Development Account, or CDE) (Strazzi *et al.*, 2008). RGR is funded by annual levies on investments by concessionaires, while the CDE was implemented in 2002 specifically for creating a new instrument to finance the universalisation of rural electricity access in Brazil.¹³ CDE resources come from a variety of sources, including payments for the use of

¹² See Eletrobrás and MME, 2009, p. 28 for a schematic overview on the current institutional structure.

¹³ It should be noted that while CDE was specifically designed to help reach universal rural electricity access in Brazil, no new financial burdens were created due to its implementation as CDE basically substituted an

public assets, fines by ANEEL to concessionaires and permit-holders, and annual quotas paid by electricity sellers (ESMAP, 2005).¹⁴ The concessionaires' participation in financing the operations is defined together with the MME and Eletrobrás, and varies on average between 10% and 15% (Instituto Acende Brasil, 2007a). As connection costs within LpT are totally free for rural consumers, in general any long-run costs occurring to the service providers (operation and management, capital, and replacement costs) following electrification are to be covered by the service providers themselves through electricity tariffs (ESMAP, 2005; Instituto Acende Brasil, 2007a). These tariffs are subsidised for small consumption levels. More than a third of residential customers (35%) in Brazil belong to the low consumer tariff sub-class. A total of 77% of the low-income consumers use up to 80 kWh of electricity per month and 23% between 80 and 220 kWh. Low-income consumers represent 43% of total consumers in the north, 62% in the north-east, 25% both in the south-east and the south, and 29% in the midwest (Instituto Acende Brasil, 2007b).

Tariff increases due to LpT had been limited to 8% in 2005, so that concessionaires and other service providers have limited possibilities to recover their operation and management costs in the long run (Instituto Acende Brasil, 2007a).

1.3 Description of current electrification programmes and objectives

Interestingly enough the creation of a programme aiming to provide universal access to electricity in Brazil gained force exactly at a time when two federal-led rural electrification programmes (LnC and PRODEEM) were still in their implementation phase.¹⁵ Most centralised concessionaires did not have clear universalisation targets, and particularly privately run concessionaires (with tight budget constraints) had little interest in promoting rural electrification because of the high costs of supplying electricity services to low-consuming, remote and dispersed households, which would make cost recovery of the investments extremely difficult (Goldemberg *et al.*, 2004; Obermaier, 2005).

As they were unable to reach substantial progress regarding rural electrification, as early as 2000 the authorities formed the idea of a universal electricity access programme that would supply electricity to all rural properties in Brazil within a five-year period (Cortez and Rosillo-Calle, 2001; Poppe, 2002). Particularly taken forward by ANEEL, the following discussions, involving a large variety of stakeholders (including representatives from other ministries, MME, Eletrobrás, ANEEL, development banks, associations of concessionaires, rural electrification co-operatives, renewable energy trade associations,

earlier power sector fund. In fact, financial contributions for the CDE remained at the same level compared with its predecessor (Poppe, 2009).

¹⁴ Other important resources come from the fuel compensation account (CCC, or Conta de Consumo de Combustíveis), which is a levy on all Brazilian electricity consumers. Today it primarily finances thermal generation via diesel in the Amazon region (ESMAP, 2005).

¹⁵ Both programmes were criticised throughout their implementation: LnC financed grid electrification for some 600 thousand households living near a grid all over Brazil over a period of three years, falling short of the initial one million households target as well as in providing inexpensive electrification (Goldemberg *et al.*, 2004; ESMAP, 2005). The PRODEEM programme provided mainly non-grid solar PV electrification to community installations, health facilities and schools. Top-down management with little local stakeholder involvement, lack of cost-recovery schemes, and lack of co-ordination with grid electrification plans severely affected the results of PRODEEM (Goldemberg *et al.*, 2004; ESMAP, 2005; Costa *et al.*, 2008).

universities and research centres, and non-governmental organisations), eventually led to the formalisation and implementation of the federal *Luz para Todos* programme (ESMAP, 2005).¹⁶

1.3.1 *Luz para Todos* targets and achievements

LpT prioritises investments that focus on productive uses of electricity and integrated local development projects – community production centres, water wells, health clinics and schools – but also seeks to service municipalities that had been left aside by the previous electrification efforts, such as indigenous areas, settlements, as well as areas with lower-than-average human development indices (HDI), regions where inhabitants are affected by hydropower dams, etc. (see Eletrobrás and MME, 2009, for the complete priority list). The target groups for rural electrification thus live mainly in the northern and north-eastern states of the country where electricity access at the beginning of LpT was lowest in both nominal and relative numbers: in the north-east 1.1 million rural households (34.4% of all rural households in the region), and in the north 447 thousand rural households (59.7% of all rural households in that region) lacked access to electric energy. Altogether, both regions thus accounted for more than 75% of the originally planned installations within LpT (Obermaier, 2005; ESMAP, 2005); both rural regions are also those with higher poverty rates and less access to other basic services (Rosa *et al.*, 2006).

Table 1: LpT rural electricity connection timetable (number of households)

	2004	2005	2006	2007	2008	2009	2010
Planned installations	218 470	496 630	490 334	356 050	381 344	510 197	578 429
Accumulated planned installations		715 100	1 205 434	1 561 484	1 942 828	2 453 025	3 031 454
Actual installations	69 999	378 046	590 013	397 877	441 427		
Accumulated installations		448 045	1 038 058	1 435 935	1 877 362		
Annual deficit	- 148 471	-118 584	99,679	41,827	60,083		
Accumulated deficit		-267,055	-167,376	-125,549	-65,466		

Sources: ANEEL (2009), Ministry of Mines and Energy (2009a).

The timetable for LpT installations until 2010 and actual achievements are shown in Table 1. When it started, the LpT programme had considerable difficulties in keeping up with the tight schedule set by ANEEL: already by 2005 the deficit of electricity connections had reached nearly 270 thousand households. Inexperience with LpT, political and administrative interferences, as well as supply shortages of material and services including cables, posts, etc. caused by the explosion of demand may explain part of these delays (Andrade, 2009b). In 2006, however, LpT's actual installations surpassed planned installations, and thus led to a declining deficit. In 2008, LpT was about 65 thousand installations short of the original targets. Finally, the pace of electrification is estimated to increase substantially until 2010, with 510 thousand new installations planned for 2009 and 578 thousand more for 2010, which is far above what had been realised the years before. These planned connections correspond mainly to the newly identified rural electrification demand – the original LpT target of two million installations had nearly been met in 2008 with 1.88 million connections.

¹⁶ Initially ANEEL published a resolution by which universal access was to be attained by 2015. With the implementation of LpT, however, this target was brought forward by seven years (2008 instead of the original end date of 2015).

At the beginning of LpT, Dilma Rousseff, Minister of the MME, defined LpT as “a proposal to reduce poverty and hunger, using electricity as a vector for development” (MME, 2003, author’s own translation). This statement underlines that rural electrification is prioritised as a key objective of Brazil’s overall poverty alleviation strategy (ESMAP, 2005), particularly regarding social inclusion of the rural poor (Goldemberg *et al.*, 2004). While prior rural electrification initiatives had concentrated mostly on increasing access to infrastructure, it was decreed that a universal access strategy should also encompass electricity consumption so as to enable the beneficiaries to use electricity as an instrument for economic and social development (Obermaier, 2005). Electricity use for the rural poor is promoted essentially through lower tariffs for low-consumption classes, the idea being that low consumption is correlated with low income (Zerriffi, 2007).¹⁷

1.3.2 Means of electrification under the LpT

In the operational manual of LpT, three technological options are listed to provide electricity to rural households: *i)* extension of grid distribution lines, *ii)* decentralised generation in isolated grids, and *iii)* individual systems. Despite these different possibilities for service providers, the Brazilian electrification model is primarily based on extension of the grid (Reiche *et al.*, 2006; Zerriffi, 2007; Andrade, 2009b). At least during the first years of LpT, grid extensions have often been the least-cost option for the utility (Zerriffi, 2007). Thus until 2009, 4.62 million posts, 883 thousand km of cable, and 708 thousand transformers have been installed within the universalisation strategy (MME, 2009b).

Large reliance on grid extension to attain universal rural access may not be economical in the future as LpT is now expected to reach out to the marginally more remote and dispersed consumers away from the existing distribution lines (Instituto Acende Brasil, 2007a; Andrade, 2009b).¹⁸ Nevertheless, according to MME, the remaining one million connections planned for 2009 and 2010 (see Table 1) will still be realised largely through extensions of the grid. It should be noted that already under the LnC phase, lack of incentives to provide low-cost connections and non-grid electrification had been perceived (Goldemberg *et al.*, 2004). Connection costs may reach USD 4 000 and more if population density is low and consumers are dispersed. These costs are well above any international benchmark, and electrification options other than grid extensions may provide much cheaper alternatives in such cases (ESMAP, 2005; Reiche *et al.*, 2006).

Renewable energy has been used very little in the beginning of LpT (Pertusier, 2004). Even by end of 2006, only around 3 100 solar home systems (SHS) had been installed under LpT, although it had been estimated that for 17 500 localities – translating into some 130 000 systems – such systems would be the most cost-effective option (IEA, 2009d). Decentralised renewable electrification options, by either individual systems or mini-grids, could play a more relevant role during the 2009–2010 period, particularly in the remote and isolated villages of the Amazon region. There are still many rural isolated communities in the Amazon that cannot be assisted by the conventional

¹⁷ This is not always the case: a study on the impacts of rural electrification in the State of Bahia in the north-east of Brazil finds that electricity consumption and income are not strongly correlated, neither on a per-capita nor at household level, although families had received electricity three years earlier (Obermaier, 2009).

¹⁸ The options used to connect rural consumers are found in the contracts established between Eletrobràs and the concessionaires or other service providers. Thus, information on the costs and technological choices are not publicly available.

system.¹⁹ However, the use of expensive diesel generators in this region is still the norm (Andrade, 2009b). It is estimated that in the Amazon region 80% of the unattended communities have less than 30 households (Amazonas Energia, 2009), and very few settlements have more than 100 inhabitants. Because of the distance from the main transmission and distribution lines, grid extension for these communities is economically unviable. With the publication of the February 2009 *Manual de Projetos Especiais* of the MME (a special projects manual that establishes technical and financial criteria to be applied for electricity services through renewable energies), the choice between which renewable energy technology to use, such as solar PV systems, wind and hybrid power plants, thermal power plants powered by natural gas or biofuels, mini and micro-hydro systems, and vegetable palm oil as a replacement for diesel imports will be done according to local conditions (MME, 2009d). However, at the moment only 23 special projects are being analysed by Eletrobrás, and there is a strong concern that diesel generators will continue to be used to attain universalisation targets if current projects fail to go beyond their pilot testing phase.

1.4 Costs, incentives and tariffs

For the ambitious targets of LpT a significant budget was set up during its implementation phase. As the LpT programme was a partnership between the federal government, the states and the concessionaires, funding resources were to be divided among the various actors, with the federal government taking up the largest share (71.5% of investments are covered by the federal government's power sector funds, 13% by the states and 15.5% by the concessionaires). The federal government's power sector funds direct more resources on loans to states with lower electrification rates and in greater need of investment, and fewer to regions whose rates are much higher. Initially LpT total costs were estimated at BRL 7.6 billion (USD 4.16 billion), with Energy Development Accounts (CDE) and Global Reversion Reserve (RGR) funds contributing BRL 5.3 (USD 2.9 billion) or around 75% to the overall budget, and the remainder being split in equal shares between the states and the service providers (MME, 2003). According to the calculations made at the time, investments were to be particularly high in the northern and north-eastern states of the country: with BRL 1.73 billion (USD 0.94 billion) and BRL 2.64 billion (USD 1.44 billion) respectively, these states would account for over two-thirds of the total planned investments (Loureiro de Azeredo, 2004). When implementation of LpT began, however, overall costs soon increased significantly. By 2007, total contracted rural electrification operations had already reached BRL 8.69 billion (USD 4.76 billion) (Instituto Acende Brasil, 2007a), implying that the originally planned budget had already been overstepped even though rural connections were still significantly behind schedule at that time (about a 125 thousand connections short, see Table 1). Current MME estimates (MME, 2009c) show that the LpT budget has further increased: the federal share is now at BRL 9.1 billion (USD 5 billion), with total investment costs estimated at BRL 12.7 billion (USD 7 billion). Therefore, in only six years, estimated LpT costs have increased by 67% over the original BRL 7.6 billion (USD 4.16 billion) initially projected.

Increased demand for connections in rural areas (one million connections more than initially identified) may be responsible for a large share of the cost increases, but it is also likely that electrification costs were simply underestimated from the start. The technical standards for rural electricity connections did

¹⁹ The long distances to these communities are only a part of the problem. Logistics are strongly affected by the tropical climate, which leaves settlements and towns completely isolated from November to April during the rainy season when rivers overflow and landscapes change completely (Andrade, 2009b).

indeed change since LpT implementation in 2003 (compare Eletrobrás and MME, 2005 and 2009), but it is unclear whether these changes had any significant impact on the overall programme costs.²⁰

1.4.1 Framework conditions and business incentives

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Eletrobrás, through the Eletrobrás' Control system, is in charge of contract management and supervision, from the establishment of the contracts to the transfer of funds. Eletrobrás uses its own monitoring methodology, carrying out sample inspections on site. At the state level, a State Managing Committee reviews and prioritises the needs of the communities, and monitors the implementation of prioritised works.

To facilitate smooth implementation of the LpT, minimise misuse of funds, reduce the risk of disruption of the work, and advance the disbursement by the concessionaires, financial transfers²¹ in the case of grid extension are conducted as described in Table 2.

Table 2: Timeline of funds release for grid extension works

Quota	Condition	Release of funds (% of the contract)	Accumulated release (%)
Initial release	After signing and complying with all legal requirements	30	30
2 nd release	With 10% of the physical progress reported by Eletrobrás Board of Engineering and corresponding financial verification	20	50
3 rd release	With 30% of the physical progress reported by Eletrobrás Board of Engineering and corresponding financial verification	20	70
4 th release	With 50% of the physical progress reported by Eletrobrás Board of Engineering and corresponding financial verification	20	90
Final release	Upon completion of the last physical inspection by the Eletrobrás Board of Engineering and final financial verification; may result in return of resources to Eletrobrás	Up to 10	Up to 100

Source: Information provided by the MME.

²⁰ Finally, it may be suggested that strong reliance on grid electrification (along with a virtual disregard of any other supply technologies), as well as difficulties to electrify remote and isolated villages in the Amazon may have driven costs upwards. No data are publicly available which could prove this assumption. To verify this, one would have to analyse the contracts between Eletrobrás and the concessionaires. They are not publicly available.

²¹ Note: if there is a previous contract in force signed under the LpT mandate, the release of funds for the new contracts will be subject to the following rules:

- I - The initial release will only occur when the physical progress of the previous contract reaches at least 60%;
- II - The 2nd release will occur only when the physical progress of the previous contract reaches at least 70%; and
- III - The 3rd release will occur only with the credit closure of the previous contract.

Table 3: Timeline of funds release for stand-alone systems

Quota	Condition	Release of funds (% of the contract)	Accumulated release (%)
Initial release	After signing the concession contract and in compliance with all legal requirements	30	30
2 nd release	Subject to financial accountability of the quota anticipated at the contract signing, as well as the confirmation of purchase and receipt of materials and equipment by the State Management Committee Coordinator of LpT	Up to 60	Up to 90
Final release	After proof of financial performance and physical inspection by Eletrobrás Board of Engineering, to be held after receiving the final commissioning report by the service providers	Up to 100	Up to 100

Source: Information provided by MME.

Since 2009, alternative electricity sources that fall within the focus of the Special Projects Manual (MME, 2009d) receive 85% of the electrification costs in the form of grants from the CDE, with the remaining 15% to be financed by the service providers. Total funds are released according to the timeline presented in Table 3.

1.4.2 Customer tariffs

Beneficiaries of LpT usually pay discounted consumer tariffs owing to their low consumption level. These so-called “social tariffs” are not linked to LpT, but available also to urban consumers. Those who use up to 30 kWh per month pay only 35% of the regular residential tariff, while those consuming between 31 kWh and 80 kWh per month pay the reduced tariff of 60% of the regular residential tariff. Under certain circumstances a 10% discount can be obtained even by consumers who use less than 140 kWh/month to 220 kWh/month (with the upper limit varying regionally), but who must also prove that they have a low income. In the states of the north and the north-east 43% and 62% of all consumers fall within the social tariff classes, which are the highest rates for all Brazil (Instituto Acende Brasil, 2007b). It should be noted that these regions also display the highest poverty indices and lowest access rates to a variety of public services. Although low income does not always correlate with low consumption levels, recently connected households that live below or near the poverty line rarely consume high amounts of electricity but rather around 30 to 40 kWh per month (Obermaier, 2005 and 2009).

In 2007, the average electricity tariff in Brazil was BRL 252.91/MWh (USD 138.5/MWh), with residential consumers paying BRL 293.59/MWh (USD 160.8/MWh) and industrial consumers paying BRL 216.61/MWh (USD 118.7/MWh).

1.5 Country-specific challenges and how they were addressed

Management of the networks

The LpT programme was created from an already consolidated electricity sector structure, with concessionaires having to abide by their system operation and maintenance obligations and to

follow the regulations in force. A concessionaire is therefore responsible for the management of the installed networks, unless it has transferred its obligations to a permit-holder, for example. In the case of isolated and remote communities in the Amazon (where costs are extremely high) independent producers (that is without a concession) may become the main actors in supplying and maintaining rural electricity services. The Special Projects Manual of the MME (MME, 2009d) sets the technical, financial and management criteria for the use of renewable energy technologies in electrification of isolated communities.

Means for future capacity expansion

The focus on household electrification under the LpT programme seems to have led sometimes to an undersizing of capacity, including isolated diesel generators in the Amazon region and solar PV systems (Zerriffi, 2007). However, no further commitments have been made by the Brazilian government regarding future capacity expansion once universal electricity access has been reached. Given the unfavourable economics of rural electrification, it can thus be expected that no further efforts will be made in the near future to increase loads. If consumers desire better-quality supply, they would have to contact their service providers directly.

Revenue collection

One of the challenges of the LpT programme is to bring electricity to remote and isolated areas, such as in the north, where the programme has not achieved its goal. The current concern is that concessionaires may have difficulties in collecting bills in systems that use renewable energies. For this reason, the 2009 Special Projects Manual (MME, 2009d) encourages projects that include a prepaid solution, whereby consumers pay in advance for the electricity they expect to use, and within their financial capacity. Moreover, remote monitoring computer systems are being connected to central systems for better supervision.

Involvement of the rural communities in the decision-making process

Under the LpT, rural dwellers themselves request the installation of electricity directly to the concessionaires. These requests are then analysed and prioritised by State Management Committees (CGE) according to the characteristics of the locality. To date, 26 Brazilian states have State Management Committees, which are composed of members of the federal government, the state government, the concessionaires and rural electrification co-operatives, regulatory agencies, mayors and the civil society. These committees meet regularly to assess requests and prioritise work. The involvement of the civil society is fundamental in the electrification process, as it improves the planning and implementation process and gives communities a sense of ownership of the electrification process.

Progress monitoring

As mentioned before, Eletrobrás uses its own monitoring methodology through on-site inspections. At the state level, a State Managing Committee reviews and prioritises the needs of the targeted communities, and monitors the implementation of the works. This monitoring is linked to the release of funds for further works, and allows to follow-up the work of the concessionaires.

Implementation of other policies in parallel to the LpT

The Comissão Nacional de Universalização (National Universalisation Commission, CNU), which is part of the LpT institutional structure and formed by Brazilian federal ministries, including the MME, the Brazilian Development Bank (BNDES) and the Regulatory Agency ANEEL, establishes policies and directives for electricity use to promote integrated rural development. The MME has also established united action protocols with other ministries so as to facilitate the improvement or even the creation of basic health and education services, water supply, and communication in the communities, along with rural electrification. The Brazilian *Bolsa Família* income transfer

programme and other recent activities such as a social housing project or the national biodiesel programme are examples of policies designed for the same groups targeted by LpT, namely the rural poor. Together, these activities may lead to a more sustainable rural economic development.

More direct actions under LpT include the construction of so-called Centros Comunitários de Produção (CCP), community centres which are to promote a rational and efficient use of electricity for productive purposes. Initially CCPs were to be installed throughout Brazil (MME, 2003) but the total number is expected to be relatively low. For example, Eletrobrás has so far managed to establish only three CCPs, none of which is located in remote and poor municipalities. The MME is currently in the process of contracting specialists which are to work directly with CCPs, so that more efforts in this regard can be expected.

In 2008, the federal government launched the *Programa Territórios da Cidadania* (Territories of Citizenship Programme). This programme is a joint ministerial effort to promote economic growth through territorial development to improve the quality of life of the people living in rural or poor regions. The MME has joined other ministries in this effort currently implemented in 120 selected territories and to be ended in 2010.

The LpT programme makes hardly any room for energy efficiency policies. There is only one example in the current version of the LpT operational manual, which states that the complete kit to be installed with the electricity connection will contain fluorescent lamps which are more efficient (Eletrobrás and MME, 2009). Otherwise, no comprehensive approach seems to have been taken to ensure efficient energy use by the new consumers.

Other country-specific challenges and how they were addressed

Several country-specific challenges regarding LpT rural electrification were identified: *i)* reaching universal access by concessionaires that in some cases are in great financial difficulties, *ii)* finding technological and organisational solutions for the Amazon region, and *iii)* ensuring long-term sustainability of the programme once funds have run out. Most of these challenges had been identified even before LpT was implemented. Given that they have not been addressed properly, most problems remain (Poppe, 2009).

The concessionaires have access to the Energy Development Accounts (CDE) and Global Reversion Reserve (RGR) funds as well as to state subsidies in order to finance installations for rural consumers to receive free electricity access under LpT. According to the overall funding schemes, fewer subsidies are granted to states with higher electrification rates and where electrification can be achieved at lower cost, whereas states with low rural access and higher costs receive larger federal subsidies. Such flexibility allows for relatively uniform tariffs throughout the country, so that customers in remote places do not have to pay disproportionately high bills because they are difficult to reach by the concessionaires or other service providers.

Combined with this, in some cases, a concessionaire may have many consumers with low consumption levels to whom the so-called social tariffs apply. These discounted tariffs make cost recovery extremely difficult even with LpT subsidies, particularly for utilities that in addition have low rates of rural electricity access (ESMAP, 2005). In these cases, privately owned concessionaires often charge their wealthier, urban consumers higher tariffs in order to cross-subsidise rural consumers. Public concessionaires with softer budget constraints are usually allowed to show losses, thus reducing the need to cross-subsidise (Zerriffi, 2007). However, as the current rural electrification strategy could well lead to rapidly rising electricity tariffs, the tariff impact of LpT was limited to 8%, which in turn strongly affected the concessionaires' ability to proceed with rural electrification. In case the tariff impact would rise above 8%, original universalisation schedules would have to be postponed until the conditions within the concession area had improved, insofar

as continued electrification could be undertaken without going beyond the 8% limit. In fact, since 2005 there have been twelve cases of concessionaires that had to interrupt their rural electrification programmes before reaching universal access because of this restriction (Instituto Acende Brasil, 2007a).

Furthermore, ensuring cost recovery under LpT poses problems. Service providers are likely to still require subsidies even after LpT reaches its universalisation target. This is because costs for operation and management, capital and replacement have to be incorporated into the calculations by the service providers (Instituto Acende Brasil, 2007a). Where low consumption levels remain, concessionaires are expected to face serious problems, especially if they are already in financial difficulties. Finally, it should be noted that the current model also creates problems in case of a greater use of distributed generation technologies. For example, independent producers implementing mini-grids are unlikely to use cross-subsidisation mechanisms when the consumer base is small, thus making it impossible for the producer to charge the social tariffs (Zerri, 2007).

Finally, the rural isolated communities, located for the most part in the Amazon region, will be serviced through the guidelines of the Special Manual Projects. But since these guidelines have been released at a very late stage (in 2009), only a few projects have yet been undertaken.

1.6 Rural electrification progress, assessment and conclusion

The Brazilian LpT rural electrification programme is now well known internationally because of its ambitious targets and its success in carrying out the necessary investments and installations. In Brazil, LpT was since its beginning considered as one of the few programmes with the potential to significantly improve living conditions in rural Brazil (Loureiro de Azeredo, 2004). While operations have been lagging behind the originally agreed universalisation plans, the current pace of LpT installations is such that the 2010 deadline is within reach. In June 2009, the number of connections had surpassed two million so that over ten million people have now benefited directly from LpT. The original target (two million rural connections) established in 2003 has been met. However, reaching universal access in the poorer and sparsely populated northern and north-eastern states has proven to be a more difficult task (Instituto Acende Brasil, 2007; Poppe, 2009). It is estimated that up to 2010 another million connections will be brought to the rural areas of Brazil, benefiting to some five more million people (Presidency of the Republic, 2009). Considerable difficulties can be expected for this last million connections, as grid electrification may no longer be a feasible option for many communities, particularly in the Amazon region. According to the MME, grid extension will continue to play a substantial role in connecting the remaining one million households within LpT.

Table 4 summarises the actual results of LpT including the latest data available for 2009.

Table 4: Rural electricity connections installed under LpT in Brazil and by region

(including information until May 2009)

	North	North-east	Midwest	South-east	South	Brazil
Accumulated installations	342 755	995 665	143 219	357 009	161 787	2 000 435
Number of beneficiaries	1 713 775	4 978 325	716 095	1 785 045	808 935	10 002 175

Source: Ministry of Mines and Energy (2009a) for geographical regions; Presidency of the Republic (2009) for Brazil. All five regions together do not add up to total number for Brazil because sources are different.

The postponement of the original 2008 deadline can be explained by several factors: the number of rural households to benefit from electricity access was greatly underestimated; occasionally administrative inexperience or interferences by various stakeholder levels; delays by service providers because of their obligation to limit the tariff impact of LpT to 8%; higher costs and sometimes depleted stocks for electrification material and services. Nevertheless, it should be acknowledged that even with the postponement of the deadlines, LpT schedules are still impressive, and missing the 2008 target should not have come as a total surprise.

While there is little doubt that LpT will succeed in providing universal access to electricity, it is important to note that several obstacles need to be overcome not only regarding the current focus on electricity access, but also regarding questions about the financial and economic long-term sustainability of the programme. The twin policies of universal access (high costs) and low tariffs (low revenues) for concessionaires lead to a very difficult situation even when accounting for the subsidies the utilities receive (Zerriffi, 2007) as operation and management, capital and replacement costs need to be covered by the service providers in the long run.²² The dominance of grid electrification – even when little productive use can be expected in the near future – is causing this problem, further compromising the financial balance of the utilities. Promoting productive uses of electricity in order to raise utilities' revenues is thus vital to guarantee the long-term success of the electrification installations once LpT comes to an end (Zerriffi, 2007).

Despite the efforts to promote such uses, the impacts of LpT so far seem to be much more on the consumption side than on the production side. An *ex post* study on the benefits of LpT found that, thanks to the programme, households find their living conditions significantly improved. Furthermore, purchases of household appliances such as TVs, refrigerators and sound systems have increased. Other positive impacts of LpT are better conditions to study, for longer hours during the day and the evening, as well as increased work opportunities (MME, 2009). It is unclear whether these perceived benefits will eventually result in, for example, higher family incomes.

²² This is the case for service providers that cannot show losses, particularly privately owned concessionaires.

2 China

China, with strong political will, extended its electricity grids and exploited the country's hydropower and solar potential. China achieved an electrification rate of 99.4% in 2009, with rural areas reaching 99% and urban areas 100% (IEA, 2009b). Over the last ten years, rural electrification has slowed down because of nearly complete nationwide electrification. The emphasis is put on modernisation, service and quality improvements, poverty alleviation and introduction of innovative technology solutions for the remaining non-electrified remote areas in the vast western regions of the country. China will now focus mainly on the use of decentralised power systems to supply, by the end of 2020, most of the people who are still without electricity.

2.1 Introduction and country description

China, with a land area of 9.6 million square kilometres, is the world's third-largest country by geographical extent. China, with 22 147 km of land boundaries, shares its borders with a total of 14 countries, namely, Afghanistan, Bhutan, Burma (Myanmar), India, Kazakhstan, Kyrgyzstan, Laos, Mongolia, Nepal, North Korea, Pakistan, Russia, Tajikistan and Vietnam. China is characterised by three climatic zones: tropical, subtropical and temperate.

Economic data and investment

In 2008, China's economy grew by 9%, with a gross domestic product (GDP) of USD 4 400 billion (bn). The primary sector amounted to USD 501.6 bn (11.3% of GDP), the secondary sector to USD 2 138.4 bn (48.6% of GDP) and the tertiary sector to USD 1 764.4 bn (40.1% of GDP) (National Bureau of Statistics China, 2009). If measured in purchasing power parity (PPP), China's GDP grew to USD 7 903 bn in 2008, ranking second after the United States (World Bank, 2009b).

In China, foreign investment is generally driven by directives from the central government that sets detailed rules for numerous parameters such as technology, location and investment size. China proactively guides and encourages foreign investments in new and renewable energies, while restricting investment in conventional coal-fired power plants. At present, procedures for approval of foreign direct investment (FDI) projects are in accordance with the "Regulation on Guiding the Direction of Foreign Investment" (February 2002, Decree of the State Council) and with the "Decision of the State Council on the Reform of Investment System", July 2004).

With respect to investment in energy structures, under "The Directory of Industry for Foreign Investment" (revised in 2007), foreign investment is encouraged in "the construction and operation of hydropower stations, giving priority to electricity", and "the construction and operation of new energy power stations (including solar energy, wind energy, magnetic energy, geothermal energy, tidal and wave energy, biomass energy, etc.)". Foreign investment is prohibited in "the construction and operation of coal-fired steam-condensing power plants with the stand-alone capacity of 300 000 kilowatts (kW) and below, the coal-fired dual units of steam-condensing and extracting, heat and power co-generation plants with the stand-alone capacity of 100 000 kW and below, outside the range of Tibet, Xinjiang, Hainan minor power grids".

Population and its economic profile

With a total population of 1 325 bn people in 2008 (World Bank, 2009c), China ranks first in the world. Almost half of the population (45%) live in cities while 55 % live in rural areas. In the past,

subject to a strict local residence permit system, domestic migration from rural to urban areas was nearly impossible. In recent years, rural to urban migration has been more prominent. In this context, latest estimates suggest that China's urbanisation rate will increase by nearly 1% per year during the next 15 to 20 years, which represents around 300 million people who will move from rural areas into cities (China Daily, 2009). Today, China's average population density is approximately 138 per km² (Wikipedia, 2009b), but with extreme variations in rural population densities, ranging from less than one to more than 400 per km². In stark contrast, the highest urban population density per km² is 50 000 to 60 000 as in the case of central Beijing, Shanghai and Chongqing (China Daily, 2009).

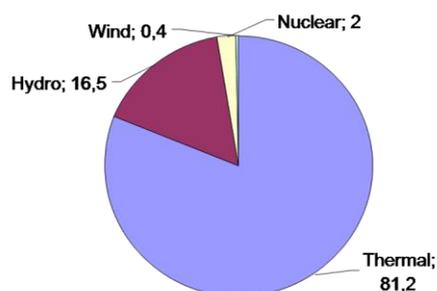
Of the total working population, 40.8% are employed in agriculture, 26.8 % in industry and 32.4% in services (National Bureau of Statistics of China, 2008). With China's rapid economic development, the income of Chinese residents has risen steadily. In 2008, the gross national income per capita per atlas method amounted to USD 2 770 (global country ranking 130 out of 210 countries) and accordingly purchasing power parity amounted to USD 6 020 (global country ranking 122 out of 210 countries) (World Bank, 2009d).

At the end of 2008, China's national employment amounted to 774.80 million people, of which 39.01% lived in urban areas. A total of 40.07 million people in rural areas lived below the poverty level,²³ defined as CNY 1 196²⁴ (approximately USD 75) per capita per annum (National Bureau of Statistics of China, 2009).

Electricity generation and consumption

In 2008, total electricity production amounted to 3.45 trillion kWh, an increase of 5.6% compared to 2007. Thermal power accounted for 81.2% of total production, with hydropower accounting for 16.5% and nuclear energy for 2%. Forecasts for 2009 suggest that total power consumption will increase by 3.5%, to 3.56 trillion kWh. According to estimates by the Power Economic Research Institute of the State Grid Corporation, national consumption of electricity is expected to reach approximately 3.94 trillion kWh by 2015 and approximately 7.425 trillion kWh by 2020 (State Grid Corp. Power Economic Research Institute, Jiang Liping, 2009).

Figure 2: China's national power generation structure (in %) in 2008



Source: State Grid Corp. Power Economic Research Institute, Jiang Liping (2009).

In 2007, total electricity consumption amounted to 3.27 TWh, comprising of 58.8% urban consumption and 41.2% rural consumption (NBS and NDRC, 2008).

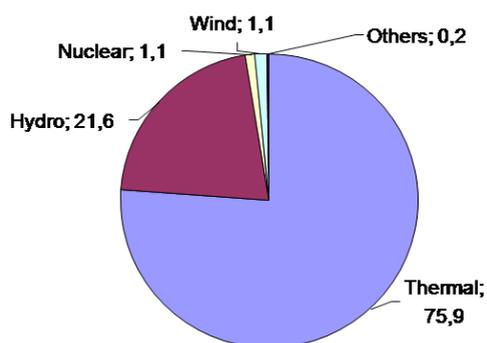
²³ There is no information regarding urban poverty.

²⁴ Chinese yuan (CNY) have been converted in USD using the 6 October 2009 exchange rate between the two currencies. 1 USD is equal to CNY 6.83640 and 1 CNY into USD 0.14671 (source: <http://www.oanda.com>).

Installed capacity and energy consumption

By the end of 2008, China's total installed power generation capacity amounted to 793 GW, an increase of 10.4% since 2007. In 2009, an additional 80 GW is expected to be installed, and by 2020 total capacity should more than double, reaching 1 600 GW with thermal power accounting for 65% (State Grid Corp. Power Economic Research Institute, Jiang Liping, 2009). Owing to its coal-dominated energy supply structure, thermal power generation capacity accounts for more than 75% of total installed capacity and China ranks first worldwide in hard coal²⁵ production, producing 47.4 % of the world's total hard coal in 2008 (IEA, 2009c).

Figure 3: China's power generation capacity (in %) in 2008

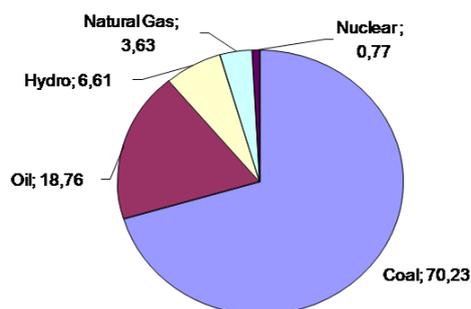


Source: State Grid Corp. Power Economic Research Institute, Jiang Liping (2009).

China's 2008 total energy consumption amounted to 1 995 million tonnes of oil equivalent (Mtoe) with coal accounting for 70%. In 2008, total consumption amounted to 2.74 bn tonnes (a 3% increase compared to 2007) of which approximately 40 Mt of coal had been imported. In the first half of 2009, approximately 48.2 Mt were imported, an increase of 126.3 % (State Grid Corp. Power Economic Research Institute, Jiang Liping, 2009). Total consumption of oil in 2008, mainly used in the transport sector, amounted to 360 Mt with domestic production accounting for roughly half. China, after the United States and Japan, is the third-largest oil importer in the world. Recent estimates by the Energy Research Institute (ERI) of China suggest that by 2020, the oil consumption may reach 620 Mt, of which approximately 60% will have to be imported. Although its share in total energy consumption has increased over the years, natural gas only represented 3.63% of total energy consumption in 2008. The government is seeking to increase that share to 10% by 2020 (State Grid Corp. Power Economic Research Institute, Jiang Liping, 2009).

During the 11th Five-Year Plan (2006-2010) the Chinese government plans to reduce energy use per unit of GDP by 20%. In this context, a reduction of 1.79% was achieved in 2006, 4.04% in 2007 and 4.59 % in 2008 leading to a cumulative reduction of 10.4% (Energy Research Institute Han, Wenke 2009). Additional efforts will be needed to reach the 20% target.

²⁵ Including recovered coal.

Figure 4: China's energy consumption structure (in %) in 2008

Source: Energy Research Institute, Han, Wenke (2009).

Institutions involved in the power sector

Over the past 50 years, China's power management system has been in the process of continual adjustment and changes. Before 1985, China centralised planning and management of the power industry system, whereby the only decision-making body was the central government which was directly responsible for production and allocation of resources. The system was managed through a combination of central government and enterprises, and all investment and operation funds were allocated by the State, while all the revenues were allocated to the Treasury. In 1985, the State Council approved the "Provisional Regulation on Encouragement of Fund-raising for Power Plants and Implementation of Varied Prices", with the introduction of a new principle whereby the enterprise now runs the power plant and the State manages the grid. Provinces were then also allowed to manage power. The central government therefore gradually relaxed the regulation and control on market access and pricing of the power industry, and at the same time delegated part of the authority to local governments. Since then, the Chinese electricity market has shifted from central planning to more private investment, competition and less regulation. Relevant policies are therefore frequently adjusted and it is difficult to predict how far this liberalisation process will go in the future.

Today, authority over the energy sector at the national level is distributed over a dozen of governmental agencies of which the National Development and Reform Commission (NDRC) plays the most important role. Such a wide distribution of responsibilities has impaired co-ordination, formulation, implementation and enforcement of energy policies. In its latest attempt to create an effective national energy institution, the government established the National Energy Commission (NEC) and the National Energy Administration (NEA) in March 2008. The latter has a broad mandate, which includes drafting energy plans and policies, negotiating with international energy agencies, and approving foreign energy investments. A more detailed overview of NEA's individual departments is shown in Table 5.

Despite being a formal establishment, the NEA lacks the authority to set energy prices, which has remained with the NDRC. Although, the NEA submits suggestions concerning energy price adjustments to the NDRC, it is the latter and ultimately the State Council whose approval is required for any major energy price change. In China, the responsibility for electricity pricing rests with the State Electricity Regulatory Commission (SERC), an independent regulator established under the State Council in 2003. The SERC performs administrative and regulatory duties with regard to the national electric power sector in accordance with prevailing laws and regulations.

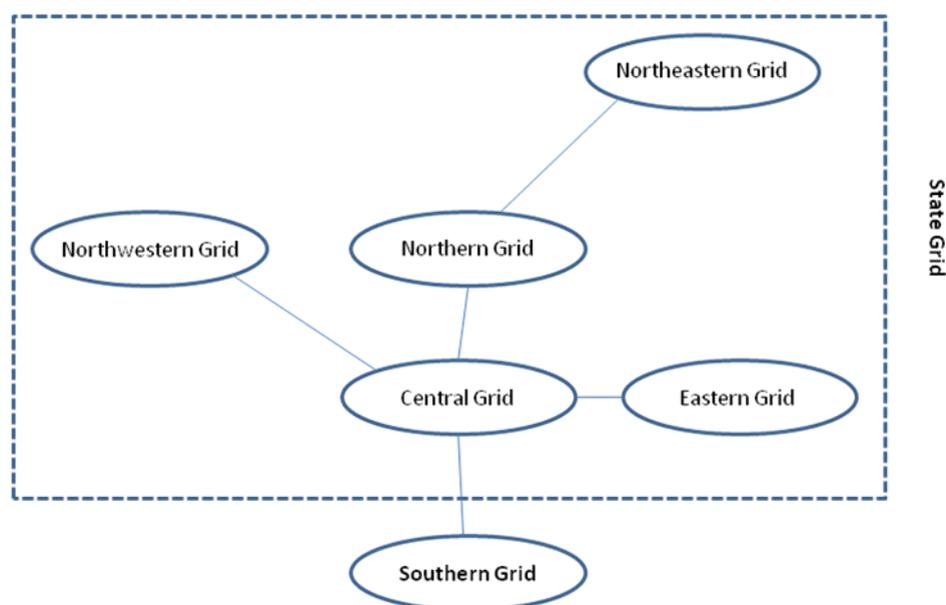
Table 5: Overview of China's national power institutions

State Council		
National Energy Commission (NEC)		
National Development and Reform Commission (NDRC)		
National Energy Administration (NEA): Departments and responsibilities		
General Administration	Policy and Legislation	Development and Planning
Manages the administration's daily operations, including personnel, Chinese Communist Party, financial management, asset management, and press affairs.	Studies important energy problems, organises the drafting of energy legislation, and conducts administrative auditing and reviews.	Studies and provides suggestions on energy development strategy; organises the drafting of macro-level energy development programmes, yearly plans, and industrial policy; and undertakes energy industry reform work.
Energy Conservation and Scientific Equipment	Power	Coal
Directs energy conservation and comprehensive resource use, promotes energy saving technologies and equipment, and prepares standards.	Plans thermal and nuclear power development, manages the national power network, and handles crisis management in nuclear power stations.	Manages the coal industry, drafts plans for coal mining, undertakes system reform, and develops advanced technology for reducing pollution caused by coal burning.
Oil and Natural Gas	New and Renewable Energy	International Co-operation
Manages the oil and gas industry, plans oil and natural gas development, promotes industry reform, and manages national and commercial oil reserves.	Directs and co-ordinates rural energy development and plans the use of new and renewable energy.	Undertakes international energy co-operation, drafts strategies, laws, and policies for opening up China's energy sector and coordinates the development and use of overseas energy.

Source: Downs (2008).

China's grid system

China's national grid is divided into the "State Grid Corporation of China" (SGCC) (comprising of five sub-grids in the north, connected to a sixth "Central Grid", together supplying a population of approximately 1.1 bn people) and the "China Southern Power Grid" (CSPG) (south China, supplying a population of 230 million) as shown in Figure 5 and Table 6. In this respect, distributed power generation through stand-alone systems is becoming increasingly confined to areas with very low population density and to remote regions of the vast west of the country.

Figure 5: China's power grid structure

Table 6: China's power grid companies

Power Grid	Area	Regions	Acreage (thousand square kilometres)	Population reached (in million)
State Grid Corporation of China SGCC	Northern Grid	Beijing, Tianjin, Hebei, Shanxi, Shandong and the west region of Inner Mongolia	1 250	230
	North-eastern Grid	The three north-eastern provinces and the districts of Chifeng and Tongliao in Inner Mongolia	1 200	100
	Central Grid	Hubei, Henan, Hunan, Jiangxi, Sichuan and Chongqing	1 200	380
	Eastern Grid	Shanghai, Jiangsu, Zhejiang, Anhui and Fujian	471	240
	North-western Grid	Shaanxi, Gansu, Qinghai, Ningxia Hui Autonomous Region and Xinjiang Uygur Autonomous Region	3026	96.22
	Tibet Grid	Central Tibet Grid (Lhasa, Shannan, Xigaze, Nagqu) and Qamdo, Linzhi, Arli power grids, and the rest are county networks	350	120
China Southern Power Grid CSPG		Guangdong, Guangxi, Yunnan, Guizhou and Hainan provinces	1 000	230

Source: State Power Information Network (2009). Website is mainly in Chinese.

China's current electrification status

Authority concerning rural electrification policy planning and financing is located at central and provincial levels, but is also shared among different government institutions. Related responsibilities may differ regionally and are usually difficult to locate in the relatively complex administrative system.

In 1996, with the introduction of the Electric Power Law, the State began to implement preferential policies for rural electrification, giving major support for ethnic minority settlements, remote areas and poverty stricken areas. Moreover, the central government promoted the development of water resources in rural areas, building small and medium-sized hydropower stations to boost rural electrification. The State encouraged and supported the use of solar energy, wind energy, geothermal energy, biomass and other energy sources so as to increase the power supply in rural areas. In 1999, the State Council approved the “Notification on Accelerating the Reform of Rural Power Systems and Enhancing Rural Power Management” (the State Council Doc. No. 2 1999), which carried out a comprehensive structural reform of the management of rural electrification which affected rural power marketing, rural power prices, power grids, investment and management. The reform introduced, among other things, a practice whereby rural and urban residents in one province would pay the same price for electricity. In 2002, the State Council’s “Circular on Program of Power System Reform” (the State Council Doc. No.5 2002) introduced the practice of “Separation of Power Plants from Grid, and Bidding for Generation”, and the State Power Corporation was split into the two power grid companies and five power generation groups. In 2007, the General Office of the State Council issued “Views on the Implementation of Deepening the Reform on Power System during the Eleventh Five-Year Plan Period” (The General Office of the State Council Doc. No.19 2007), which standardised the restructuring of power enterprises at the county level, and encouraged the involvement of independent power companies. Since 2007, the State encourages all types of investors to invest in rural power grids.

Table 7: Un-electrified households and populations (early 2006)

No	Province	Households	Population	No	Province	Households	Population
1	Yunnan	503003	2189361	18	Shanxi	12744	50976
2	Sichuan	476707	1939150	19	Ningxia	12664	49650
3	Tibet	212431	1200668	20_1	Liaoning	10854	33403
4	Inner Mongolia	186658	746632	20_2	Dalian City	9821	44670
5	Guangxi	163302	727892	21	Fujian	4797	20901
6	Chongqing	153699	552297	22	Hebei	2800	11909
7	Gansu	123936	523394	23	Hunan	31074	124595
8	Henan	134472	505372	24	Hainan	8700	35000
9	Qinghai	89488	495372	25	Jiangsu	--	--
10	Shaanxi	126838	477831	26	Anhui	--	--
11	Guizhou	111830	466350	27	Beijing	--	--
12	Xinjiang	95300	415700	28	Shanghai	--	--
13	Hubei	72947	243482	29	Tianjin	--	--
14	Guangdong	47938	238417	30	Jilin	--	--
15	Jiangxi	45854	191434	31	Zhejiang	--	--
17	Xinjiang Military	23234	78106	33	Total	2695681	11467438

Source: EU-China (2009).

As a consequence of China's efforts, the national electrification rate in 2009 was 99.4%, with rural areas reaching 99% and urban areas 100% (IEA, 2009b). In 2006, a total of 11.5 million people were still lacking electricity access (see Table 7), with wide variations among provinces. In late-2007, 11.5 million people had still no access to electricity (March 2008, China Mid and Long-Term Renewable Energy Development Plan by 2020, NDRC). Latest statistics from the National Energy Administration suggest that in 2008, 2 million rural households still lacked electricity in China, which represents some 9 to 10 million people (Tang, 2009). Through the deployment of decentralised power systems, the government aims to supply 10 million people with electricity by the end of 2020. The government however expects that beyond 2020 some Chinese households will still be lacking electricity.

2.2 Institutional structure for rural electrification

The institutional structure responsible for the Chinese electrification process underwent numerous changes in the course of the last 50 years. Today, along with the realignment of formerly vertical planning structures of the 1990s, rural electrification programmes and projects are hosted by numerous entities, divided horizontally by administrative levels and vertically by topic.

2.2.1 Institutional structure – implementing agencies

At present, five major government institutions have different functions and responsibilities in the field of rural electrification. In addition to the State Electricity Regulatory Commission (SERC), the State Grid Corporation of China (SGCC), the Ministry of Water Resources (MWR), the Ministry of Agriculture (MOA) and the National Development and Reform Commission (NDRC) are all considered to be influential in the field of rural electrification. In general, the NDRC approves the rural electrification programmes proposed by the National Energy Administration (NEA). The department for new and renewable energy of the NEA deals with the bulk of planning related to rural electrification. Recently, the NDRC released two guiding documents concerning rural electrification: China's Renewable Energy Development Plan (2006-2010) released in March 2008, and China's Mid and Long-Term Renewable Energy Development Plan until 2020, released in September 2007.

Regarding the actual electrification efforts, implementing actors differ according to whether electrification is undertaken through grid extension or through decentralised systems.

In the case of decentralised electrification, actual implementation is being done through competitive bidding procedures such as in the Township Programme or occasionally through single source selection. Implementation agencies can be formerly government-owned companies, start-up companies that were formerly government-owned enterprises, or private companies. In general, ownership is very challenging to determine, as China is moving from 100% government-owned enterprises to private ownership, and the various forms of ownership are often not entirely transparent. In the case of rural electrification through grid extension, the State Grid Corporation of China and the Chinese Southern Power Grid proceed to the actual implementation.

In the case of electrification through grid extension, implementation is undertaken by the grids themselves.

2.2.2 Institutional structure – funding

According to the regulation contained in "Views on Accelerating the Reform of the Rural Power System and Enhancing the Rural Power Management", the central government has primarily

increased investment for rural power grid construction and transformation through loans from the Agricultural Bank of China. Apart from these loans, power companies are encouraged by the central government to seek funding for their activities through normal loan procedures. Local governments at all administrative levels are also required to increase their support for rural power grid construction, and provincial power corporations can borrow funds from them as well. Nowadays there is a wide variety of financing sources – government and private – available, through grants, loans, direct investment and in-kind contributions (Yao & Barnes, 2007). Government subsidies are usually linked to development programmes that include the promotion of new technologies (e.g. photovoltaic systems, small-scale wind turbines, biogas applications), electrification of areas with unfavourable conditions or social measures such as poverty alleviation.

In 1987, a special interest-bearing loan for rural energy was created by the government. This loan mainly supported large-scale biogas projects, solar thermal, and small-scale wind power technologies. By 1996, the loan amounted to approximately CNY 0.12 bn (USD 17 million). The interest on the enterprises' loan was subsidised 50% by the commercial bank. This special loan supported the promotion of the small-scale wind turbine industry and off-grid wind power. But today, centrally planned rural electrification programmes using decentralised renewable energy applications are entirely financed either by the central government or through a cost-sharing scheme which features a financial contribution by the respective provincial government. The “Township Electrification Programme”, which financially supported the construction of off-grid renewable energy systems (hydropower, photovoltaic systems, wind) in eleven provinces over 2002-2005, featured a joint financing scheme. The level of social and economic development in each of the eleven provinces determined the level of funding granted by the central government. In Tibet, for example, the central government covered 100% of the cost incurred by electrification efforts, whereas in Qinghai only 80% and in Sichuan only 50% of the costs were covered. Therefore, financing commitment for renewable energies is ensured by the government. In addition, the government will formulate and implement rural renewable energy tax policies and regulations that encourage public and private investment in renewable energy service companies (RESCOs) and that ensure extensive renewable energy applications in the vast rural areas of China. China will also provide tax incentives on renewable energy technology development and utilisation, on technical research and development and on equipment manufacturing (NDRC, 2008).

2.2.3 Institutional structure – recovery process

At present, China's rural power management system follows the principle of “one county²⁶ one power supply enterprise”, ensuring the integrated power management at all administrative levels within a county. Therefore, all dwellers in a county are supposed to pay the same price for electricity. Power supply enterprises charge fees according to the household consumption recorded by metering at the national ratified electricity price. Electricity metering devices are certified by the government. Both are measures to unify and standardise the electricity management and supply structures (metering, billing, price) and at the same time to improve the quality of the service (reliability, electrical stability).

²⁶ Counties are in the third level in the administrative hierarchy of China.

2.3 Description of current electrification programmes and objectives

In China, the traditional approach to providing electricity to rural areas is mainly through grid extension. However, the long transmission lines often result in a small load and huge line losses. At present, most regions without electricity are located in western regions and islands in the eastern coastal areas, far away from the grid. Most of these areas are rich in renewable energy resources (hydropower, solar and wind energy) which can practically and economically provide electrification to remote regions. In rural China, electricity is supplied through three channels: a county is connected to a national grid, or is supplied through local dispatch, or is self-supplied. Following this pattern, China implemented the “Brightness Programme” and the “County Hydropower Construction of National Rural Electrification”, using small hydropower, wind and solar power generation for the electrification of rural areas.

2.3.1 Historical rural electrification and expected end-use

Development of China's rural electrification can be divided into three main stages (Peng & Pan, 2006). During the first stage (1949-1977), rural communities were the main investors in rural electrification efforts; during the second stage (1978-1997) the central, provincial and local governments all played fundamental roles; and during the third stage (since 1998) the central government is the main investor. In 1997 the government noted that rural electricity supply suffered from a number of problems. First of all, the rural grid was old, leading to unreliable and unsafe electricity supply. Often the grid had been badly planned and built, leading to poor electricity quality and supply disruptions. Large wire losses were pushing electricity tariffs to extremes (Peng & Pan, 2006). As a consequence, in 1988 the government launched a major reform of the rural power management system, transformed and renovated the rural grids with a view to unifying electricity prices for urban and rural dwellers within a same grid. Seven years of grid reconstruction and transformation have cost USD 49.5 billion to the Chinese government.²⁷ The provincial grid companies managed and operated the renovation of the rural grids, while the costs of network improvement were amortised through the national electricity tariff. Thanks to these efforts, the structure of rural power grids were improved and safe operation enhanced the reliability (to 99.7%) and the quality of power supply. Moreover, losses due to transmission of high-voltage grids dropped to 10%, while losses in low-voltage grids dropped by 30% to 45% compared to 12% before the grid improvement.²⁸ This significantly reduced electricity prices in rural areas and facilitated the levelling of electricity prices, leading to strong growth in the demand for electricity.

Over the last ten years, rural electrification has slowed down as a result of nearly universal electrification (around 99%). At present, the emphasis is on modernisation, service and quality improvements, poverty alleviation and introduction of new technologies (Yao & Barnes, 2007) and innovative solutions for the remaining non-electrified remote areas in the vast western regions of China. Table 8 illustrates the characteristics of the five main periods of Chinese rural electrification.

²⁷ Data provided by the Institute of Energy and Environmental Protection (IEEP), and the Chinese Academy of Agricultural Engineering (CAEE) for this Information Paper.

²⁸ Data provided by the IEEP.

Table 8: Stages of rural electrification in China between 1949 and 2009

Period (years)	Percentage of rural population with access to electricity	Expected end-use as formulated by government	Principal means of electrification	Percentage of electrified rural households NOT connected to national grid
1949-1957	Very low	No formulated expectation	Locally manufactured small hydropower	90 (estimation)
1958-1978	61	Irrigation, agricultural processing, rural small industry	Small hydropower (simple domestic technology and imported from former Soviet Union)	80 (estimation)
1979-1987	78	“Rural economic development”, better rural living standard	Small hydropower (improved domestic technology), small thermal applications	60 (estimation)
1988-1997	97	“Support the industrialization of the rural economy”	Grid extension, small hydropower (improved domestic technology)	37 (for 1997; by county [Peng & Pan, 2006])
1998-present	>99	Use of rural electricity be no longer limited by technical insufficiencies or non-standard price	Grid extension, small hydropower, other renewable energies e.g. PV, PV/wind hybrid, solar home systems (SHS), small scale wind turbines	22 (for 2000; by county [Peng & Pan, 2006])

Sources: Pan *et al.* (2006); Yao & Barnes (2007).

2.3.2 China’s current rural electrification programmes and achievements

Brightness Programme and Township Electrification Programme

In 1996, the then State Development Planning Commission (SDPC) (called National Development and Reform Commission, NDRC, since 1996) launched the so-called “Brightness Programme” the aim of which was to supply approximately 23 million people living in remote rural areas with electricity services by means of decentralised energy systems based on renewable energy resources such as hydropower, solar and wind by 2010. The goal was to provide 100 watts of capacity per person. During a pilot phase (1999-2002) in Inner Mongolia, 5 500 hybrid PV/wind/battery household systems; in Gansu 10 000 solar home systems (SHS); in Tibet 30 PV/battery village power systems and 11 000 SHS were installed. According to estimations, approximately 50 000 persons had been supplied with electricity. As part of the Brightness Programme, the so-called “Township Electrification Programme” (2002-2005), with a total investment of CNY 4.7 bn (USD 0.69 bn) consisting of special central and local government funds, was used to supply electricity to 989 rural townships and villages throughout western China. By the end of this programme, 1.3 million people had access to electricity by means of PV, PV/wind hybrid, and small hydropower stations (NDRC, 2008).

In 2002 and 2005, 842 737 people were supplied with electricity through the Township Programme (see Table 9).

Table 9: Township Electrification Programme – overview of beneficiary households²⁹

Province	People electrified by PV & PV/wind	Households electrified by PV & PV/wind	People supplied by hydro	Households supplied by hydro	People supplied by SHS	Households supplied by SHS	Total number of people supplied with electricity	Total number of Households supplied with electricity
Tibet	141 635	28 966	176 824 (133 072)	33 680 (25 341)			318459 (274707)	62646 (54307)
Qinghai	40 650	8 640			32 000	6 800	72650	15440
Xinjiang	65 237	13 654	5 640	1 500	13 800	2 886	84677	18040
Xinjiang Corps	16 386	4 762			5 248	4 247	21 634	9 009
Inner Mongolia	11 369	2 840			6 100	1 525	17 469	4 365
Gansu	37 942	4 165	39 380	5 853			77 322	10 018
Sichuan	24 900	5 500	33 8000 (81 480)	75 000 (18 080)			362 900 (106 380)	80 500 (23 580)
Shaanxi	1 865	520	2 4875	6 968			26 731	7 488
Chongqing			234 720 (59 940)	83 351 (26 472)			234 720 (59 940)	83 351 (26 472)
Yunnan			12 807	2 258			12 807	2 258
Jiangxi			16 100	3 983			16 100	3 983
Hunan	420	100	71 900	18 000			72 320	18 100
Total planned			920 246	230 593			1 317 789	315 198
Total accomplished	340 404	69 147	445 194	108 455	57 148	15 458	842 737	193 060

Source: UNDP China (2008).

In 2007, after completion of the Township Electrification Programme, rural electrification continued with the “Power Construction for Un-electrified Regions” managed by provincial utility bureaus. The programme worked mainly through grid extension and small hydro while some provinces used PV systems (mainly SHS) for remote places. Total installed power generation capacity of the projects amounted to less than 3 MW. In 2008 alone, approximately 800 kW were installed.³⁰

²⁹ Numbers in brackets are real achievements. When they are noted, this signifies that there was a difference between the target and the achievement. No bracket means that the targets were achieved.

³⁰ Data provided by Frank Haugwitz.

Figure 6: Township Electrification Programme – map of installed systems

The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Source: Map provided by Frank Haugwitz.

County Hydropower Construction of National Rural Electrification

The “County Hydropower Construction of National Rural Electrification” programme of the Ministry of Water Resources seeks to build a total of 400 high-standard rural hydropower electrification systems in 400 counties, thereby providing electricity to 880 000 people without electricity and to 4.85 million people with insufficient electricity provision by 2010. Moreover, water authorities are responsible for building small hydropower stations to replace conventional energy sources for cooking and heating, supplying 1.7 million rural households (around 6.77 million people). The goal is to ensure electricity access to at least 99.9% of China (Chen Lei, 2009).

By the end of 2008, 45 000 small hydropower stations were installed with a combined capacity of 51 GW, supplying electricity to 300 million people living in rural areas with hydropower sources.³¹ In this context, the electrification rate in rural hydropower areas increased from 40% in 1980 to 99.96% in 2008. In the course of the 10th Five-Year Plan the central government spent CNY 115.5 bn (USD 16.94 bn) to support the construction of 410 small hydropower stations with a total capacity of 10.6 GW, or 30 MW per county (Chen Lei, 2009).

Power for All

The aim of the State Grid Corporation’s “Power for All” programme is to reach 4.5 million people (1.2 million households of the 1.5 million without electricity) in 26 provinces, autonomous regions and municipalities by 2010. As can be seen in Table 10, at the end of 2007, out of a total of 498 235 administrative villages within the State Grid Corporation of China, only 1 694 administrative villages were still without electricity, an electrification rate of 99.66%. Moreover, out of a total of 192 308 000 rural households within the State Grid Corporation’s area, 250 000 households were without electricity, an electrification rate of 99.87% of households. According to the State Grid Corporation, almost every province has realised electrification through grid extensions except for the sparsely populated north-western provinces of Tibet, Xinjiang and Qinghai (State Grid Corporation, 2008).

³¹ This impressive result derives from sustained efforts from the Chinese government to electrify the country through small hydropower applications. This surpasses the “County Hydropower Construction of National Rural Electrification”.

Table 10: State Grid Corporation's achievement in electrification of administrative villages and households in 2007

	Total	Total electrified	Electrification rate
Administrative villages	498 235	1694	99.66%
Households	192 308 000	250 000	99.87%

Source: State Grid Corporation of China (2009).

China Southern Grid Electrification Efforts

The China Southern Grid Company aims to have completed the construction of power grids at the county level by 2010, investing a total of USD 7.2 bn for the supply of electricity to 410 000 households through grid extension. At the end of 2008, out of a total of 63 249 administrative villages, only 37 (all located in Yunnan Province) still lacked electricity access, with an access rate of 99.94%. Moreover, out of a total of 47 614 000 rural households 232 800 were without electricity, a rate of 99.51% (State Electricity Regulatory Commission, 2009).

Table 11: China Southern Grid's achievement in electrification of administrative villages and households in 2008

	Total numbered in 2007	Total unelectrified	Electrification rate
Administrative villages	63 249	37	99.94%
households	47 614 000	232 800	99.51%

Source: China Southern Grid Corporation (2009).

Golden Sun Programme

In late July 2009, the Ministry of Science and Technology (MOST), the Ministry of Finance (MOF), and National Development and Reform Commission (NDRC) jointly announced to financially support the deployment of up to 500-600 MW of large-scale solar PV in both on-grid and off-grid areas by 2012. The programme aims at all provinces with a cap of 20 MW per province. Investments for on-grid solar power projects will be 50% subsidised by the government and off-grid systems will be 70% subsidised. Subsidies are conditional on the requirement of 20 years service life of the installation.

2.3.3 Total achievements: all programmes taken together

Table 12 illustrates the distribution of the remaining un-electrified households/populations for each province in early 2006.

Comparing Table 13 with Table 12, between December 2001 and early 2006, the number of non-electrified households was reduced from over 7 million to close to 2.7 million by means of grid extension, decentralised renewable energy systems, resettlements, etc. This means that more than 4 million households gained access to electricity in almost 6 years.

Table 12: Status of un-electrified households and population (early 2006)

No.	Province	Households	Population		Province	Households	Population
1	Yunnan	503 003	2189361	18	Shanxi	12744	50976
2	Sichuan	476 707	1939150	19	Ningxia	12664	49650
3	Tibet	212 431	1 200 668	20_1	Liaoning	10 854	33 403
4	Inner Mongolia	186 658	746 632	20_2	Dalian City	9 821	44 670
5	Guangxi	163 302	727 892	21	Fujian	4 797	20 901
6	Chongqing	153 699	552 297	22	Hebei	2 800	11 909
7	Gansu	123 936	523 394	23	Hunan	31 074	124 595
8	Henan	134 472	505 372	24	Hainan	8 700	35 000
9	Qinghai	89 488	495 372	25	Jiangsu		
10	Shaanxi	126 838	477 831	26	Anhui		
11	Guizhou	111 830	466 350	27	Beijing		
12	Xinjiang	95 300	415 700	28	Shanghai		
13	Hubei	72 947	243 482	29	Tianjin		
14	Guangdong	47 938	238 417	30	Jilin		
15	Jiangxi	45 854	191 434	31	Zhejiang		
17	Xinjiang Military	23 234	78 106	33	Total	2 695 681	11 467 438

Source: Center for Renewable Energy Development, JKD, Beijing (2006).

Table 13: Non-electrified villages (December 2001)

No.	Province	Total villages	Non-electrified villages (%)	Total number of households	Non-electrified households	Non-electrified households (%)
1	Tibet	7 306	71.96	367 000	289 300	78.83
2	Guizhou	25 847	13.07	7 087 000	1 294 000	18.26
3	Inner Mongolia	13 993	16.87	3 477 000	249 590	7.18
4	Sichuan	55 042	2.72	19 589 000	648 300	3.31
5	Ningxia	15 616	8.36	810 000	64 000	7.90
6	Hubei	32 662	3.21	986 4000	121 500	1.23
7	Gansu	17 803	5.87	4 403 000	488 700	11.10
8	Qinghai	4 054	19.09	671 000	101 000	15.05
9	Guangxi	14 816	4.72	8 779 000	388 600	4.43
10	Henan	48 436	1.45	19 121 000	577 000	3.02
11	Xinjiang	8 934	6.30	1 872 600	316 200	16.89
12	Yunnan	13 432	3.93	8 064 000	100 3800	12.45
13	Hunan	49 849	1.04	14 417 000	279 500	1.94
14	Hebei	50 027	0.80	14 016 000	13 800	0.10
15	Fujian	14 970	2.34	6 302 000	33 000	0.52
16	Shaanxi	31 969	1.08	6 860 000	289 100	4.21
17	Shanxi	32 365	0.80	6 122 000	112 000	1.83
18	Hainan	2 633	9.61	999 000	160 300	16.05
19	Chongqing	20 647	0.79	7 098 000	191 900	2.70
20	Jiangxi	20 677	0.24	7 206 000	287 000	3.98
21	Anhui	30 558	0.16	12 565 000	80 500	0.64
22	Heilongjiang	14 387	0.09	4 377 000	9 100	0.21
23	Liaoning	16 310	0.02	6 638 000	4 800	0.07
24	Guangdong	22 945	0	13 198 000	50 800	0.38
25	Jilin					
26	Shandong					
27	Jiangsu					
28	Zhejiang					
29	Beijing					
30	Tianjin					
31	Shanghai					
Total			3.81a		7 053 790	3.84

a. Excluding figures for Natural Villages in Gansu and Qinghai.

Source: UNDP China (2008).

2.3.4 Means of electrification

Preference for resource-relevant technologies

Grid extension has always been the favoured option when it came to China's rural electrification. Where decentralised solutions existed, they were usually considered as preliminary electrification measures. From the point of view of end-users living in rural areas, electricity generated from decentralised renewable energy systems was perceived as "inferior" and "not always available" and therefore not the most favoured option. But recently, renewable energy technologies, both grid-connected and stand-alone, were perceived as viable options for electricity production. This change in perception is true for both the Chinese government and the Chinese population.

Today, the increasing difficulties to bring electricity to the remaining villages in the far west of the country by grid extension, has led to questioning whether "full grid coverage" is economically justified compared to using cheaper decentralised off-grid options. Because the last 11.5 million un-electrified people are difficult to reach through grid extension, the government now aims to supply electricity to 10 million people by the end of 2020 through the deployment of decentralised power systems (China's Mid and Long-Term Renewable Energy Development Plan until 2020 released by NDRC in March 2008). Providing electricity to populations in remote, off-grid areas is a clear objective of the ongoing 11th Five-year Renewable Energy Plan, primarily featuring the deployment of clean and renewable energy in the following order of priority: small hydro, PV village systems, PV/wind hybrid systems, small wind turbines, and solar home systems. In areas with strong hydropower potential, small hydro projects will be developed as a priority, because of the lower cost per kWh generated. In areas with no water resources, small solar PV stations, PV/wind hybrid stations, small wind turbines, solar home systems will be installed to provide electricity to over 1 million households by the end of 2010. Target areas are Tibet, Qinghai, Inner Mongolia, Xinjiang, Yunnan, Gansu, and others. Today, one-third of the total rural electricity consumption is supplied by local small hydropower (Chen Lei, 2009).

Preference for locally made stand-alone technologies

In the late 1990s some equipment like small wind turbines, PV, SHS, had to be imported, because in most cases these projects were part of bi- and/or multi-lateral technical co-operation. However, in the course of the Brightness Programme, and notably the Township Electrification Programme from April to July 2002, five nationwide public tenders were conducted to select system integrators³² to design, procure and install systems. Almost all equipment was domestically manufactured. Even in projects financially supported by the German Bank for Reconstruction (Kreditanstalt für Wiederaufbau, KfW), the equipment was locally produced except for the PV modules and inverters.

2.3.5 Description of expected end-use of electrification

In the framework of rural electrification through decentralised renewable energy systems, the Chinese government considers supplying electricity only for lighting, TV and radio as means to support both basic social and economic development goals. Productive use of electricity by households, as in the case of the Township Electrification Programme, is prohibited because it is rightly expected that electricity demand would soon exceed the capacity of the installed battery system. Frequent replacements of battery banks would consequently cause higher costs for operation and maintenance. In isolated cases, end-users have however purchased small processing

³² These system integrators are former government-owned companies, start-up companies from former government-owned or privately-owned companies. Ownership is often unclear to determine in China.

equipment such as flour-grinding machines, oil seed pressing equipment, or even welding machines to generate additional income.

The distribution of end-use appliances has considerably changed over time. Table 14 illustrates the starkly different distribution of common household appliances between rural and urban households and also reflects China's enormous economic development in the course of the last decades (Pan *et al.*, 2006).

Table 14: Electric appliances in rural and urban households (per 100 households)

Items	1980		1990		2000		2004	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Washing machine	1.9	48.3	9.1	78.4	28.6	90.5	37.3	95.9
Refrigerator	0.1	6.6	1.2	42.3	12.3	80.1	17.8	90.2
Air conditioner	0	0	0	1.1	1.3	30.8	4.7	69.8

Source: Pan *et al.* (2006).

Recent statistics from the National Energy Administration suggest that in 2008, 99.2% of rural households have colour television sets, 49.1% have washing machines, 30.2% have refrigerators and 9.8% have air-conditioners. This is a huge advance in rural households' quality of life (Tang, 2009).

The government sees electrification in poverty-stricken rural areas through small hydropower as a means to improve production, promote economic and social development, and increase the income of rural dwellers through employment opportunities provided by growing industries (Chen Lei, 2009). Electricity generated through hydropower systems is therefore expected to raise rural incomes and facilitate the social and economic development in rural areas.

2.4 Costs, incentives and tariffs

2.4.1 Costs

Rural grids

Since 1998, China has invested more than CNY 400 bn (USD 58.68 bn) in construction of power plants in rural areas (Tang, 2009) of which USD 49.5 billion over the past seven years.³³ By the end of 2005, the State Grid Corporation had invested over USD 27.89 billion in two phases of rural power grid renovation (State Grid Corporation of China, 2009); USD 5.98 billion was invested in the renovation of county power grids and USD 50.81 million in the renovation of the western power grid; 20 % of these investments came from Treasury Bonds as capital, the remaining 80% from bank loans. After the renovation of the rural grids, the depreciation cost and financial cost of the State Grid Corporation have increased substantially. According to the "Rural Grid Programme for the Eleventh Five-Year Period by the State Grid Corporation", during the period covered by the plan, the estimated investment in rural grids by the Corporation will be USD 16.57 billion, of which USD 3.31 billion of capital, and USD 13.26 billion of bank loans. The average annual investment will be USD 3.26 billion, of which USD 0.65 billion of capital, and USD 2.61 billion of bank loans.³⁴

³³ Data provided by the Institute of Energy and Environmental Protection (IEEP).

³⁴ Detailed cost data for the programmes of the Southern Grid Corporation of China are not available.

Brightness Programme/Township Programme

The national “Township Programme”, authorised by the State Council in 2001, was initiated in mid-2002 with the goal to supply electricity to the remaining 1 065 administrative townships³⁵ in rural western China. The programme has cost CNY 4.97 bn (USD 730 million) of which CNY 2 bn (USD 293 million) came from the central government and the rest from provincial and township governments. Through a competitive bidding procedure at the provincial level, the so-called system integrators responsible for the installation, operation and maintenance for three years were selected. Most systems were installed during the mid-2002 to 2004 period. In total, 989 power stations were constructed of which 721 are PV and PV/wind hybrid systems with a total capacity of 15.53 MW and 146 small hydropower stations with a total capacity of 113 MW.

The subsidy needed to facilitate the operation of decentralised renewable energy systems, mainly photovoltaic, amounted to a total of approximately CNY 20 million (USD 2.93 million), the average subsidy being about CNY 2 900/kW of installed capacity in one year.

2.4.2 Framework conditions and business incentives

Historically, rural electrification through grid extension or decentralised renewable energy applications in order to achieve nationwide electrification is the mandate of the government. This mandate is reflected in previous and future Five-Year National Development Plans that outline relevant rural electrification undertakings with their corresponding budget.

In late 2002, worldwide experience with PV and PV/wind hybrid systems in villages – seen from institutional, social, economical, environmental and technical angles – was extremely limited. This explains why the private sector did not engage in the implementation of the Township Electrification Programme. The main actors remained government-affiliated institutions or semi-private entities such as spin-off companies from former government institutions previously involved in rural electrification projects and that had already gained experience. In this context, because certain criteria had to be fulfilled to be selected as participant in the competitive bidding procedure, companies with a track record were in an advantageous position compared to “potential newcomers in the business”. Moreover, when selecting the so-called “system integrators”, these were considered responsible for the construction, maintenance and operation of these decentralised village power systems for three years, and contracts stipulating tasks, responsibilities and modes of payment were signed. Since all constructed systems were off-grid, no public-private partnerships had to be arranged. As of today, although the contracts came to an end, some system integrators still operate, maintain and organise the supply of spare parts, and train local technicians for these off-grid systems.

2.5 Country-specific challenges and how they were addressed

China is currently facing challenges in its objective of 100% rural electrification.

Theft and vandalism

China has no official statistics regarding electricity losses due to theft or vandalism whether for rural grids or stand-alone systems. However, theft and vandalism do occur and are perceived as problems which require an urgent solution. In the absence of effective supervising mechanisms,

³⁵ From an administrative point of view, once these remaining townships are electrified, China will have attained 100% electrification of townships (excluding administrative villages, villages and natural villages where the other 11 million people are living).

damage and theft of equipment have become a serious concern in that they affect the operation of power plants. There is a widely shared view that measures need to be taken during the system construction itself. In the case of the Township Electrification Programme, in late 2006 stolen PV modules were reported to the responsible Provincial Department of Reform and Development Commission with a view to obtain funding for replacements. In some cases, PV modules have been welded to the basic structure so as to create additional hindrances for potential thieves. By comparison, privately owned local systems are under better control, especially solar home systems, small-scale wind turbines and pico-hydropower stations, and are therefore less subject to theft and vandalism.

Prohibitive operational costs

For decades, China's focus has been on securing power supply for urban and industrial use. As a consequence, the gap in service supply between urban and rural areas has been growing. Rural areas remained relatively under-developed, and growth in electricity use was slow, seasonal and fluctuating over the day. Long transmission lines, coupled with low load density, have resulted in high costs for rural power supply and little or no business revenues. Moreover, because of past management practices of some county power suppliers, these were heavily indebted and the majority of their workers were unskilled. These prohibitive operational costs have discouraged potential investors. Centralised structures, rooted in history and politics, were preferred, resulting in grid extensions to areas with high construction costs, transmission losses and maintenance expenses, instead of opting for decentralised solutions.

However, with its goal to electrify an extra 10 million people by 2020 through the use of locally available renewable energy resources, and the sharp fall of application costs for renewable energy systems during the last decade, China is striving to become the world market leader for PV and wind energy technology. The lower costs incurred by growing domestic demand will be a strong economic incentive for greater industry involvement.

Low quality of rural electricians

Before the reconstruction of rural grids, the low level of electrification in rural areas required work from only ordinary unskilled electricians. These were usually farmers whose main income came from agriculture, but who worked part-time for electricity companies, even collecting the bills as part of their tasks. However, with electrification spreading to rural areas, the technological complexity of electricians' work increased. The need for constantly improving electricity services has expanded the rural electricity market. Rural electricians are now required to work full-time while upgrading their skills. With relatively low wages and an often insecure revenue flow, no medical insurance and no pensions, skilled electricians are difficult to find and very few residents in economically developed villages want to become electricians. There is no suitable training available, and most of the new local technicians/operators have not received any technical training and therefore are unable to perform operation and maintenance (O&M) tasks. The government is therefore in the process of identifying mechanisms and institutions, preferably at provincial level, to ensure that potential candidates benefit from a standardised training in operation and maintenance tasks.

Operation and maintenance reliability for off-grid

Commercialisation by private-sector companies bears the risk that after-sale support is neglected owing to low profitability. Moreover, with the rapid implementation of the programme, insufficient consideration was given to user training, and only a minimum budget allocation for training purposes was earmarked in the original budget. The most common perception in the past was that "electricity is a hands-on business" where no special qualification was required. Today, with increasing technical complexity, it is essential to train members of the villages/townships. However,

here again, the lower level of education among the rural population makes it difficult to recruit people with a basic knowledge of mechanical or electrical engineering, who would be ready to follow the training courses provided by system integrators, project owners or the like. In general, once off-grid applications have been installed, at least two inhabitants of these villages/townships will be appointed by the village/township government to serve as rural technicians and to perform basic operation and maintenance tasks such as cleaning PV modules, checking batteries, collecting electricity fees, replacing fuses, fixing disconnected wires, and so on.

2.6 Rural electrification progress assessment and conclusion

China has made major efforts to restructure its energy system and provide electricity to its remote areas. It has succeeded in tackling the problems of electrification by using different renewable energy power systems, and abandoning grid extension efforts when these were not economical or practical. During the electrification process, China has faced numerous challenges some of which remain to be addressed. However, rural electrification in China is no doubt a success story that has led to near-complete electrification of the most populated country of the world in a relatively short period. Since this process started several decades ago, a distinction should be made between the older and recent processes.

Keys to historical rural electrification success

Pragmatism overcame ideology, in the sense that although the central government had absolute power and clear plans on how to electrify the country, it yielded administrative responsibility to local levels in support of a different approach, more efficient and appropriate to the situation. The price that had to be paid for the rapid initial electrification included inconsistent tariff structures, administrative responsibility overlaps, low technical quality of installations and often small electrical capacities that were suitable only for a limited range of applications.

Keys to recent rural electrification success

The recent and ongoing rural electrification activities are characterised by technically advanced programmes to supply electricity to areas with difficult conditions.

Government commitment: Whether through grid extension or decentralised off-grid applications, universal supply of electricity has been one of the government's objectives. As a socialist country, China aims to give all its citizens the same basic living conditions, including access to electricity. As with other rural electrification programmes, the government's commitment (through efficient planning and sufficient long-term funding) has proven most fundamental to the electrification success.

Technological flexibility: The "last remaining un-electrified areas" means areas that are "hardest to electrify", with the highest costs if inappropriate means are chosen. This situation was avoided by choosing a wide array of technologies to prove their respective competitive advantages. The Township Programme was among the first to use technologies such as PV hybrid systems on a large scale. Moreover, the use of small hydropower plants in water-rich areas, as in the "County Hydropower Construction of National Rural Electrification", has brought resource-specific answers to electrification concerns.

Sense of ownership: Areas with low population density require individual household systems where operation, maintenance and ownership are in the same hands. In China, operation and maintenance worked best if a strong sense of ownership was present as far as individual

applications like pico hydropower, solar home systems and small-scale wind generators were concerned.

Private-sector implementation entities: The competitive bidding procedure of the Township Programme sought to minimise implementation costs. However, not all participants to the bidding process were equally capable of performing the tasks, since formerly government-owned companies had a competitive advantage in that they had acquired experience in rural electrification.

Remaining challenges linked to grid extension

Complex administrative structures: Even though rural electricity supply now lies in the hands of large power companies after a reform to unify the electricity system, strong county- and township-level government influence on the management of small hydropower still prevails. There is an overlap of responsibilities between the central, provincial and county government players in the management of rural electrification and it is not always clear who is ultimately responsible for the operation and management of rural electrification structures. This problem still needs to be addressed to improve the fluidity and long-term viability of the electrification process.

Low level of rural power consumption: According to 2009 IEA calculations, China's total per-capita electricity consumption had reached 2 328 kWh in 2007, a 14% increase since 2006. There remains a strong urban-rural divide in electricity consumption. This shows that additional and significant electrification efforts are needed and that economic development has not yet fully propelled rural households to the levels of urban households.

Pricing: The Chinese pricing policy remains unclear. There is no market pricing mechanism for electricity since prices are still set by the government. Power suppliers are therefore not assured the necessary profits. This particularly affects the long-term investment security for investors in county-level power systems. Rural power grids are unattractive to investors owing to these market uncertainties. The example of the Yunnan Province demonstrated that rural end-users limited their monthly electricity consumption to a level that makes it completely unattractive to the electricity company to invest further in infrastructure and maintenance.

Lack of competition in the county: Supply companies targeting rural areas have always enjoyed a monopolistic position. According to the Chinese “one county one supplier” policy, the supplier is to provide the full range of services at a given price. Market access by other investors is difficult if not impossible. This, along with rigid rules on production, supply and marketing of electricity, prevents innovation, competition and reform.

Prohibitive maintenance costs and lack of funding: Rural grids incur major construction and maintenance costs. Although there are maintenance fees, they are insufficient to cover the expenses of the ever-increasing assets. Two-thirds of the fees collected through rural electricity tariffs are used for building electricity generators, and the remaining third is insufficient for acquiring maintenance equipment for grid renovation or development (Luo, 2007). These financial burdens negatively impact business revenues. In addition, in the course of the energy sector reform which began in 1998, some electricity facilities of the rural grids have been corroded, damaged, or generally could not meet the demand, and thus needed either replacement or modification, again incurring large expenses. The improvement of living standards and the economic development of rural areas, a consequence of electrification, stimulate electricity demand, and put power supply companies under permanent financial strain. Rural grids need constant renovation and maintenance.

Main remaining challenges linked to the Brightness Programme/Township Programme

Use of unsuitable material: As a first step towards the ambitious objectives of the Brightness Programme, a three-year pilot phase was launched in 1999 in three provinces. A survey conducted by the Institute of Electrical Engineering (JKD) in Inner Mongolia in late 2003 (Chinese Academy of Science, 2003) revealed that out of 5 240 PV/wind/battery hybrid systems for which statistics were available, a total of 2 119 systems (40.4%) were malfunctioning. Problems with the inverters/charge controllers accounted for 1 099 sets (20.9%) followed by 657 problems with batteries (12.5%) and 363 problems with wind turbines (6.9%). On-site investigations suggested that the bearings of wind turbines were made out of unsuitable copper material. The main causes of the exceptionally high proportion of malfunctioning charge controllers/inverters were poor technical design and the utilisation of unsuitable material during assembly. Consequently, the malfunctioning charge controller/inverter shortened the lifetime of 657 batteries. As a result, a general dissatisfaction among end-users prevailed and led in many cases to the refusal to pay the final instalment for the systems. Table 16 provides an overview of future costs to 2020.³⁶

Unclear long-term operation and maintenance: When the Township Electrification Programme was designed, government financial support was almost entirely earmarked for the procurement of hardware. Through a competitive bidding system, system integrators were selected and according to what the bidding documents stipulated, their responsibility merely included the design, construction, operation and maintenance of the off-grid systems. However, this lasted only three years. Today, more than six years after the Township Electrification Programme was initiated, a number of pressing issues are still pending here and there, *e.g.* ownership (transfer from national to provincial/township government), management (financial and contractual requirements for Renewable Energy Service Companies, RESCOs), financial support (governmental subsidies to cover expenses incurred for operation and maintenance (O&M) during the 20 years of the system's life), tariff setting (official guidelines to set a tariff to be paid by end-users and how the difference in tariffs can be balanced through the provisions made in the Chinese Renewable Energy Law). Moreover, ownership in most of the provinces has not been defined, so that many entities are unwilling to take responsibility for operation and maintenance, causing problems in daily management, bill collection, equipment replacements and repairs, etc. Different tariffs (there is no single tariff for all townships), lead to insufficient revenues earmarked for O&M. The collection of one end-user tariff is not sufficient to cover all the costs incurred for O&M, replacement of components, repairs and the monthly salary of local technicians/operators. Thus, continued financial support from the government is indispensable.

Long-term technical reliability: Many technologies used in the electrification programme have never been applied on a large scale and some were even specifically developed for this programme. This poses the question of long-term reliability of the technologies applied.

³⁶ In the course of the survey involving 11 out of 13 system integrators, budget estimates were compiled covering the potential lifetime of village power PV systems over the 2006-2020 period. In total, four cost categories have been identified.

- Operation & maintenance of PV systems (primarily maintenance and monthly salary of on-site local operator);
- Cost to cover the technical support rendered by Renewable Energy Service Companies' routine inspection, labour, problem-solving, communication, management, reasonable profit;
- Cost to cover the replacement of equipment (twice battery replacement, major repair, other electronic devices such as inverter, controller, mini-grid);
- Other cost (training and unforeseen expenses).

Unclear financial mechanisms: Besides unclear mechanisms regarding the awarding and control of subsidies, there is no model to calculate the real cost of subsidies in support of energy generated from renewable sources. Growing energy demand at the local level is straining the entire system, notably batteries which often require fast replacement. But who is to pay? The most pressing matter is to find sufficient funding to ensure a long-term sustainable operation until 2020. In the meantime, to support the long-term financial viability of rural electrification efforts, the central government is nevertheless allocating subsidies earmarked for a number of previously implemented off-grid electrification programmes, as Table 15 shows.

Table 15: Overview of subsidy allocations for off-grid systems (October 2007 to June 2008)

Province	Project	Installed capacity (kW)	Subsidy (CNY)
Gansu	Township Electrification Programme	971	2 913 000
	China-Japan Dunhuang Danya Project	200	600 000
	China-Germany Financial Cooperation Programme	123	371 100
Qinghai	Township Electrification Programme	3943	11 829 000
	Sanjiangyuan (Region of Three Rivers) Project	519.3	1 558 125
	China-Germany Financial Cooperation Programme	366.4	1 099 200
Xinjiang	Wind Energy Co., China-Germany Wind Project Phase 1+2	100.5	301 500
		289.6	858 800
Yunnan	China-Germany Financial Cooperation Programme	100.5	301 500
	China-Germany Technical Cooperation PV Power Programme	298.5	529 199
Total		6911.8	20 361 424

Source: EU-China (2009).

In conclusion, rural electrification efforts have slowed down during the last ten years as nationwide electrification is nearly complete. China has achieved an electrification rate of 99.4%, with 99% in rural areas and already 100% in urban settings, thanks to the government's aggressive measures and strong political will. At present, the emphasis is shifting to modernisation, service and quality improvements, poverty alleviation and the introduction of new energy technologies (Yao & Barnes, 2007) and innovative solutions for the remote areas in the vast western regions of China that remain without electricity. The Chinese government estimates that only 1.5 million people will still be without in 2020.

Table 16: Operation and maintenance costs (2006 – 2020)

Province	System integrator	No. of village power PV systems	Total power capacity (kW)	Investment (CNY)	Renewable Energy Service Company (RESKO)	Battery replacement (CNY)	Operation & maintenance (CNY)	Others (CNY)	Annual (CNY)	Over 15 years (CNY)
Tibet	Beijing Corona	92	1 764.6	20 225.8	204.4	555.13	254.7	169.8	1 184.03	17 760.45
	Huaguan Tibet	49	860	9 802	29.4	228.7	73.5	9.8	341.4	5 121
	Yunnan Tianda	--	--	--	--	--	--	--	--	--
	Beijing JIKE	58	1 255	14 809	68.71	286.25	177	61.3	593.26	8 898.9
	Trina Solar	40	715	8 437	62.95	131.07	30	77.03	301.05	4 515.75
	Shanghai 811	42	1 035	12 316.5	135.92	314.66	102.15	138.7	691.43	10 371.45
Qinghai		112	2 715	27 964.5	252.48	729.25	245.15	55.83	1 282.71	19 240.65
Inner Mongolia		42	752	6 516.9	20.06	142.2	27.43	9.8	199.49	2 992.35
Gansu		20	995	11 978	61.1	266	68.48	63.87	459.45	6 891.75
Xinjiang		--	--	--	--	--	--	--	--	--
Sichuan (Yingli)		9	242	2 178	7.62	86.15	13.18	10.71	117.66	1 764.9
Sichuan (SunPower)		17	590.71	5 316.4	92.1	121.33	118.87	71	403.3	6 049.5
Shaanxi		9	100	1 105	5.53	40.08	14.88	3.49	63.98	84 566.4
Total		490	10 996.41	120 649.1	940.27	2 900.82	1 125.34	671.33	5 637.76	84 566.4
Share (%)				100	16.68	51.45	19.96	11.91	100	70.1

Source: UNDP China (2008).

3 India

With the largest rural population in the world, India is facing a huge electrification challenge. Today, 64.5% of India is electrified, with an electrification rate of 93.1% in urban settings but only 52.5% in rural areas (IEA, 2009b). This has been achieved mainly through grid extension or small-scale renewable energy systems. Strong political will and sufficient funds have, since the beginning of the 11th Five-Year Plan, accelerated the speed of electrification. But India is currently faced with insufficient electricity generating capacity, which is seriously hindering the implementation of future rural electrification programmes and undermining their viability. India's energy sector, electrification efforts and the remaining challenges are detailed below.

3.1 Introduction and country description

The Republic of India is the seventh-largest country in the world with respect to its geographical area, covering 3.29 million square km and including 7 517 km of coastline. Its terrain ranges from an elevated tableland in the south, to deserts in the west, the Himalayas Mountains in the north, and flat to rolling plains along the Ganges River.

Political context

India is a federal State divided into 28 states and 7 union territories. Since 1947, the year of its independence, it is the world's largest democracy. An elected president is the Head of State. Executive power resides with the Prime Minister, while legislative power resides with the Upper House (Rajya Sabha) and the Lower House (Lok Sabha). The 28 states have their own elected governments, and the 7 union territories are governed by an administrator appointed by central government (except for the territories of Delhi and Pondicherry). A governor for each state is nominated by the president. The Indian Constitution defines the legislative and administrative relationships between the central and state governments but some issues such as electricity and economic and social planning are the joint responsibility of both central and state governments. Depending on the issue addressed, policies and laws are either set at the central or state level but central law always prevails if state and central laws are conflicting (IEA, 2007).

In the power sector, policy setting and implementation is divided between five ministries: the Ministry of Power (MoP), the Ministry of Coal, the Ministry of Petroleum and Natural Gas, the Ministry of New and Renewable Energies (MNRE) and the Department of Atomic Energy, and government commissions and agencies. The Bureau of Energy Efficiency (BEE) is a body under the MoP which co-ordinates energy efficiency and energy conservation measures, and the Central Electricity Authority (CEA), under the MoP, acts as an advisory body to the central government on matters of national electricity policy, and specifies technical standards and norms for grid operation and maintenance among other issues. Under the MoP, the Central Electricity Regulatory Commission (CERC) regulates central and interstate-level power-related activities, while the State Electricity Regulatory Commissions (SERCs) work on state-level licensing, state-level electricity tariffs and competitive issues. Among MNRE's main activities is the expansion of the use of renewable energy technologies in remote rural areas. State governments also have considerable responsibilities in the power sector as they are responsible for the implementation of national laws. They can set their own laws and regulations to be applied on their territory. Because of this setting, the implementation of power sector reforms differs in each state (IEA, 2007).

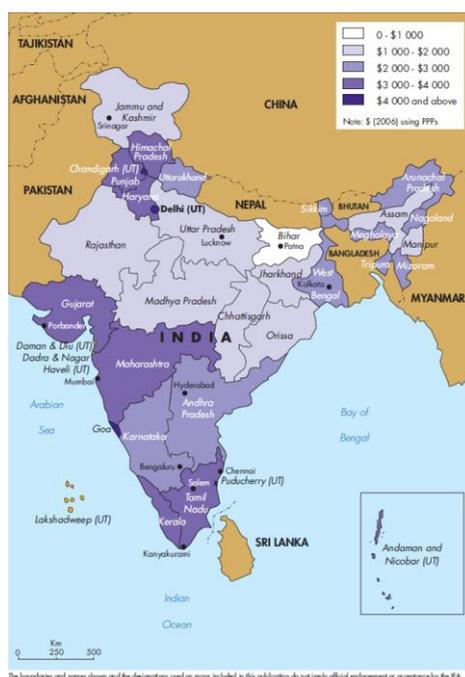
Economic data

India's gross domestic product (GDP) in purchasing power parity (in billion USD 2000) attained USD 4 024 billion in 2009 (IEA, 2009e). In 2007, services accounted for 52.8% of total GDP, industry for 29.4% and agriculture for 17.8% (World Bank, 2008). The large share of services in total GDP is remarkably high compared to most other developing economies. Average annual growth of GDP has also been high, averaging at 6.9% over the 1997-2007 period, reaching 9.7% in 2006 and 9% in 2007. Over 2007-2011 the economy is expected to grow at an average of 8.5% (World Bank, 2008). However, according to the World Bank, the 2008-2009 global financial crisis has caused India's economic growth to weaken over that period compared to the previous three years. India's Ministry of Finance expects the economy to grow by only 6.1% over 2008-2009 (Ministry of Finance, 2009).

Population and its economic profile

India is the second most populous country after China and the first most populous democracy with a total population reaching an estimated 1 139 965 million in 2008, which is about 17% of the world's population (World Bank, 2009d). According to the Central Intelligence Agency's *World Factbook for India*, in 2003, 60% of the labour force worked in agriculture, 12% in industry and 28% in services; the total unemployment rate across sectors in 2008 was 6.8% (CIA, 2009). India has the largest rural population in the world with 828 million rural inhabitants. In 2008, 70.8% of India's total population lived in rural areas, progressively migrating to urban areas at an annual rate of 2.3%, a rate which is below that of many other countries (UNPD, 2008).

Figure 7: GDP per capita per state



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Source: IEA (2007).

According to recent World Bank estimations, the GDP per capita grew by 7.7% in 2007, and is expected to grow by 7.2 % over 2007-2011 (World Bank, 2008). Over 1997-2007, GDP per capita

grew by 5.3%. While such economic development has led to an average increase in the standards of living, it has left the agricultural sector untouched, bypassing most of the rural poor. Therefore, although India has enjoyed a growth of GDP per capita, poverty remains a challenge. Poverty is also more concentrated in some states such as the eastern and north-eastern states as Figure 7 shows. India has over 300 million poor people living below the “poverty line” as defined by the Planning Commission. In March 2007, the Indian Planning Commission estimated that over the 2004-2005 period, more than one-quarter of India’s total population (27.5%) still lived below the poverty line (BPL), with a distribution of 25.7% urban dwellers and 28.3% rural dwellers (Planning Commission, Government of India, 2007)³⁷ as seen in Table 17.

Table 17: Number and percentage of people below the poverty line in India (1983-2004)

Years	Rural		Urban		Combined	
	in million	in percent	in million	in percent	in million	in percent
1983	252	45.7	70	40.8	322	44.5
1993	244	37.3	76	32.3	320	36
2004	220	28.3	80	25.7	301	27.5

Source: Planning Commission - Government of India (2008).

The government of India is hoping that rapid economic growth, coupled with access by all to the basic amenities – electricity access, health, education and clean water – will be the keys to levelling the income disparity among the rural and urban populations (Planning Commission, 2006). But strong economic growth alone does not bring such amenities to the rural poor. For this reason, the Planning Commission has been working to establish solid infrastructures such as electricity connections, telephone connections, roads, railways and irrigation so as to improve the productivity of agricultural and rural industries (Planning Commission, 2006).

Rural – urban divide: unequal access to electricity

In 2005, a total of 412 million people in India had no access to electricity, with 380 million of them (92% of total population) living in rural areas and 32 million in urban areas (IEA, 2007). According to recent IEA estimates, India is today 64.5% electrified, with an urban electrification rate reaching 93.1% and a rural rate of only 52.5% (IEA, 2009b).

³⁷ The definition of the poverty line is a major cause for international and internal debate. In India, its definition has changed considerably over the years. Since 2006, the criterion used by the Planning Commission is the monthly per capita consumption expenditure and is based on a caloric norm. Its definition is used to identify individuals who are in need of government assistance and aid. The Planning Commission considers that an individual is living below the poverty line if his or her monthly consumption expenditure is below Indian rupees (INR) 356.35 in rural areas (around USD 7 or enough to purchase 2 400 calories of nutrition) or below INR 538.60 in urban areas (around USD 10.5 or enough to purchase 2 100 calories of nutrition). Under this criterion, 27.5% of the Indian population live below the poverty line. Because of major debate over this definition, government committees have been asked to rethink the definition of the poverty line. In 2007, the Arjun Sengupta Committee estimated that a total of 77% of the Indian population lived with less than INR 20 (USD 0.4) a day, with 27.5% living under the poverty line, and some 50% living just slightly above it. In June 2009, a committee chaired by the Supreme Court food commissioner N C Saxena, and appointed by the Rural Development Ministry suggested a revision of the parameters defining a new poverty line, under which 50% of the Indian population would live. Such numbers differ from International estimations such as those of the Asian Development Bank estimating that 41.6% of the population live below the poverty line of USD 1.25 (PPP) per day (Asian Development Bank, 2009).

Installed capacity

According to the Central Electricity Authority (CEA) of the Ministry of Power (MoP), on 31 July 2009, India's total installed capacity had reached 151 073 megawatts (MW). Thermal power accounted for 60% of total installed capacity with 96 794 MW, hydropower for 24.5% with 36 916 MW, nuclear power for 2.7% with 4 120 MW and renewable energies for 8.8 % with 13 242 MW (Central Electricity Authority, 2009a).

Page | 64 According to the Ministry of Power, at present 86.5% of India's total installed capacity is publicly owned, either by the states or by the central government. A smaller share of generating capacity is covered by independent power producers (IPP) and industrial auto-producers, which according to the MoP operate 13.5 %³⁸ of all India's capacity (Table 18). State Electricity Boards own around 50% of total installed capacity. Public companies owned by the central government, including the National Thermal Power Corporation (NTPC), the National Hydroelectric Power Corporation (NHPC) and the Nuclear Power Corporation of India Ltd. (NPCIL) control around 34% of India's total capacity.

Table 18: Total installed capacity (at 31 July 2009)

Sector	Capacity (MW)	Percent
State governments	76 364	52.5
Central government	48 970	34.0
Private entities	24 987	13.5
Total	150 321	100

Source: Ministry of Power (2009b).

Table 19 shows that the western region has most of the installed capacity compared to the other regions, followed by the southern and northern regions. The eastern and north-eastern regions, traditionally the poorest regions in terms of GDP per capita (Figure 7) have also much less installed capacity. Generating capacity from renewable sources is greatest in the southern region, while the western region has the most installed thermal power capacity.

Table 19: Region-wise installed capacity

Region	Thermal (MW)	Nuclear (MW)	Hydropower (MW)	Renewable energy sources (MW)	Total (MW)
Northern region	22632.13	1180.00	13425.15	1766.37	39003.65
Western region	34100.88	1840.00	7448.50	4023.62	47413.00
Southern region	22072.02	1100.00	10993.18	7047.90	41213.10
Eastern region	16917.12	0	3933.93	227.41	21078.46
North-eastern region	1002.07	0	1116.00	171.00	2289.07
Islands	70.02	0	0	6.11	76.13
Total India	96794.24	4120.00	36916.76	13242.41	151073.41

Source: Central Electricity Authority (2009b).

³⁸ According to the *World Energy Outlook 2007*, this number reaches 27% of total installed capacity, as the MoP may not be accounting for all of the operations from industrial autoproducers.

Electricity generation

Electricity consumption per capita is among the lowest in the world, equalling 543 KWh/capita (IEA, 2009e). Although India has considerably improved its generating capacity, it still has difficulty in meeting demand and there are persistent power shortages which constrain India's economic growth. With the development of the industrial and commercial sectors as well as the wider use of electrical equipment, electricity demand keeps increasing. To meet this increasing demand, India will have to make substantial investments in the electricity sector. The country expects to increase its capacity by 78 700 MW over the 11th Five-Year Plan (2007-2012). For the long-term horizon, the report on the Integrated Energy Policy has projected energy demand to the year 2031/32 (Table 20).

Table 20: Projected electricity demand and supply to 2031/32

Year	Projected population (in million)	TPCE (Mtoe)	Projected demand of electricity		
			Total energy (TWh)	Peak demand (GW)	Capacity required(GW)
2006/07	1114	389	774	109	155
2011/12	1197	521	1167	168	233
2016/17	1275	684	1687	250	337
2021/22	1347	898	2438	372	488
2026/27	1411	1166	3423	522	685
2031/32	1468	1514	4806	733	960

Source: Planning Commission (2005).

Transmission

Before 2006, the Indian power system was composed of five regional grids operating independently, namely the Northern, Eastern, Western, Southern, and North-Eastern Grids. Each one covered several states. Since August 2006, all these regional grids except for the Southern Grid have been integrated and now operate together at the same frequency. They are now treated as if they were one single grid called the NEWNE grid. The southern grid is planned to be synchronously operated with the NEWNE grid towards the beginning of the 12th Five-Year Plan (Central Electricity Authority, 2008). Therefore, India still does not have a real unified grid and the intra-country capacity needs to be strongly increased to meet the country's needs.

Distribution and electricity losses

Distribution is the weakest link of India's power supply chain as it faces substantial technical losses (because of overloading of transformers and conductors, for instance) and commercial losses of electricity (because of low metering efficiency, poor billing and collection, large-scale theft of power) averaging 33.7% of total generation in 2006/07 with variations by state as illustrated in Figure 8. These losses are among the highest in the world. They compare to some countries in sub-Saharan Africa. They compromise the financial viability of the power sector, and discourage investment (IEA, 2007).

Figure 8: Electricity losses by state

The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Source: IEA (2007).

During the 11th Five-Year Plan, the financing needed for generation, transmission and distribution is estimated to amount to USD 241 billion, of which USD 65 billion will be allocated to generation and USD 30 billion to transmission and distribution in rural areas (Asian Development Bank, 2008).

3.2 Description of current electrification programmes, targets and achievements

Until 1997, a village was considered electrified if electricity was being used within its revenue area for any purpose whatsoever. In 1997 a new definition was adopted whereby “A village will be deemed to be electrified if electricity is used in the inhabited locality within the revenue boundary of the village for any purpose whatsoever”. Under this definition, in March 2004 a total of 74% of inhabited villages were considered electrified, whereas only 44% of the 138 million rural households (60.2 million) used electricity as a source of lighting. However, according to this definition, if only one light bulb was kept lit for a nightly hour in the centre of a village or one irrigation pump was powered, the whole village was considered electrified. Realising this inadequacy and the statistical bias that came with it, the government of India changed its definition for rural electrification in March 2004. A village was considered electrified when the following criteria were satisfied:

- “The basic infrastructure (such as distribution transformer and/or distribution lines) is made available in the inhabited locality within the revenue boundary of the village, including available power supply on demand at at least one hamlet/Dalit Basti as applicable, and any of the public places like schools, Panchayat Office (village council), health centres, dispensaries, community centres etc.; and
- The number of households electrified should be at least 10% of the total households in the village.”

As a consequence of this new definition for electrification, many villages that were previously considered electrified fell by definition into the un-electrified category.

3.2.1 The Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) scheme

Targets of the RGGVY

In February 2005, a large-scale electrification effort, the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) scheme was launched by the MoP to speed up rural electrification under the “Power for all by 2012” initiative. The RGGVY is a major programme of grid extension and reinforcement of the rural electricity infrastructure. “By 2009/10 the RGGVY aims to electrify the 125 000 villages still without electricity; to connect all the estimated 23.4 million un-electrified households below the poverty line with a 90% subsidy on connecting costs granted by the Ministry of Power; and finally, to augment the backbone network in all 462 000 electrified villages. The 54.6 million households above the poverty line which are currently un-electrified are expected to obtain electricity connection on their own without any subsidy” (Planning Commission, 2005).³⁹ The RGGVY policy therefore aims at:

- “Provision of electricity access to all households (including rural households) by year 2009 (which includes 23.4 million households living below the poverty line);
- Quality and reliable power supply at reasonable rates; and
- Minimum lifeline consumption of 1 kWh per household per day as a merit good by year 2012.” (Ministry of Power, 2008)

However, the electrification programme as envisaged under RGGVY was too slow during the 10th plan period. In January 2008, the RGGVY was further extended into the 11th plan period (2007-2012) with the following new conditions for its better implementation:

- States are to ensure a minimum of 6 to 8 hours of power supply;
- States are to ensure quality and reliable power supply at reasonable rates;
- The deployment of franchisees is mandatory for the management of rural distribution;
- Introduction of the three-tier Quality Monitoring Mechanism to ensure quality of materials and implementation; and
- States are to notify their rural electrification plans to the Rural Electrification Corporation (REC)⁴⁰ within six months.

Means of electrification in rural areas under the RGGVY

Under the RGGVY, projects would be financed for provision of the following systems:

- A Rural Electricity Distribution Backbone (REDB) with 33/11 kV (or 66/11 kV) sub-station of adequate capacity in every block where none exists;
- Village Electrification Infrastructure (VEI) with provision of distribution transformer of appropriate capacity in villages/habitations; and
- Decentralised Distributed Generation (DDG) systems based on conventional sources where grid supply is not feasible or cost-effective.

³⁹ However, based on a review recently carried out by MoP, by the end of the 11th FYP (on 31 March 2012), the RGGVY should be able to electrify 100 000 villages and provide free connections to 17.5 million households below the poverty line.

⁴⁰ The REC is the nodal agency for the RGGVY. It is a wholly government-owned enterprise responsible for the implementation of its rural electrification schemes.

Under the RGGVY scheme, the first approach to village electrification will be through grid extension. Where grid connection is either not feasible or not cost-effective, then stand-alone systems are considered which can be powered by renewable energy sources or conventional sources, namely through DDG systems. All infrastructures must be grid-compatible in order to ensure that when a village is ultimately connected to the grid, prior investments are not lost. In DDG projects of the RGGVY, the renewable energy technologies currently used are diesel generating sets powered by biofuels (non-edible vegetable oils), diesel generating sets powered by producer gas generated through biomass gasification, solar photovoltaic, and small hydropower plants. Other technologies, such as diesel generating sets powered by biogas (from animal waste), wind hybrid systems or other hybrid systems, including any “new” technology, are currently not yet popularly used for DDG in India, but may be used in the future. Moreover, although diesel is the easiest form of decentralised power generation, the government of India encourages its use only for stand-by options or in the case of temporary disruption of renewable energy supply. The general rule of thumb supposes that the technology with the lowest marginal cost and which is considered the most appropriate and effective technological option for the area will be chosen.

Achievements of the RGGVY

During the 10th plan, 235 projects sanctioned at an investment of INR 97.33 billion⁴¹ (approximately USD 2.43 billion) covered the electrification of 65 419 un-electrified villages and provision of free electricity connections to 8.31 million BPL households (Ministry of Power, 2009a). At the end of the 10th plan period (31/03/2007), 38 525 villages were electrified and 672 000 BPL households had been provided with electric connections (see Table 22).

After approving the continuation of RGGVY in the 11th plan, in September 2009, the MoP had sanctioned 332 projects for the period covering the electrification of 49 736 un-electrified villages, the intensive electrification of 242 439 electrified villages and free electricity connections to 16.2 million BPL households (see Table 21). During the 11th Five-Year Plan, focus has been on states that had a heavy backlog of un-electrified villages and BPL households, as well as on special category states (such as north-eastern states, Himachal, J & K and Uttarakhand), border districts and districts led by left wing extremism.

In September 2009, a total of 567 projects had been sanctioned under the RGGVY, covering the electrification of 118 499 villages, the intensive electrification of 354 375 already electrified villages and the free electricity connections of 24.6 million BPL households at an estimated cost of INR 262.56 billion (approximately USD 5.421 billion) as show in Table 21. The expected completion cost is estimated as INR 330 billion (or USD 7 billion) (Ministry of Power, 2009a).

Table 21: Overall status of the progress of project implementation under the RGGVY at 01/09/09

Proposals	Projects	Project outlay (billion INR)	Project outlay (billion USD)	No. of un-electrified villages	No. electrified villages	BPL households (in million)
Sanctions in 10 th plan	235	97.33	2	68 763	111 936	8.31
Sanctions in 11 th plan	332	165.23	3.41	49 736	242 439	16.20
Total sanctions	567	262.56	5.41	118 499	354 375	24.6
Total achievements		153.47 (58.4%)	3.17 (58.4%)	64331 (54.3%)	88860 (25%)	6.89 (28%)

Source: Rural Electrification Corporation (2009).

⁴¹ On 17 September 2009 USD 1 was equal to Indian rupees 48.56099, and INR 1 to USD 0.02065 (source: <http://www.oanda.com>). All values given in this chapter are converted at this rate.

Table 22: Implementation status of the RGGVY to 2009

Years	Un-electrified villages (No)			BPL households (million)		
	Target	Achieved	% achieved	Target	Achieved	% achieved
10th Plan						
2005/06	10 000	9 819	98.2	0.30	0.017	5.7
2006/07	40 000	28 706	71.8	4.0	0.66	16.4
Total 05/07	50 000	38 525	77	4.3	0.672	15.6
11th Plan						
2007/08	10 500	9 301	88.6	4.0	1.62	40.5
2008/09	19 000	12 056	63.5	5.0	3.09	61.7
Total 05-09	79 500	59 882	75.3	13.30	5.38	40.4
2009 ongoing	17 500	3 158	18	4.7	0.98	20.8
Total ongoing		63 040			6.36	

Source: Rural Electrification Corporation (2009).

The overall achievement of the RGGVY against the targets set under Bharat Nirman to be attained at end March 2012 is found in Table 23. Less than one-third BPL households and half of the villages had been electrified in September 2009.

Table 23: Overall achievement in September 2009 with respect to Bharat Nirman targets

	Target	Achieved	% achieved
Village electrification	125 000	64331	51
Connections to BPL households	23.4 million	6.89 million	29.4

3.2.2 The Remote Village Electrification (RVE) Programme

Targets

Since 2005, the RVE programme of the Ministry of New and Renewable Energies (MNRE) has been supplementing the efforts of the Ministry of Power (MoP) through complementary measures for the provision of basic lighting/electricity facilities through renewable energy sources. The Remote Village Electrification programme (RVE) is responsible for electrifying un-electrified remote census villages (with a population of less than 100 inhabitants⁴²) and remote un-electrified hamlets of electrified census villages where grid connection is either not feasible or not economical (because they are located in forests, hills, deserts or islands) and where DDG projects are not implemented by the RGGVY of the MoP. The scope of the RVE is the provision of electricity for:

- “All un-electrified remote census villages by 2007;

⁴² The electrification of villages comprising more than 100 inhabitants will usually be undertaken by the RGGVY scheme through its DDG (decentralised distribution and generation) projects. To avoid overlap of efforts, close co-ordination between the RGGVY and the MNRE is ensured mainly through the Rural Electrification Corporation.

- All households of un-electrified remote census villages by 2012; and
- All un-electrified remote hamlets of electrified census villages by 2012.” (Ministry of New and Renewable Energies, 2003-2004)

The RVE programme is implemented in the states by state-notified implementing agencies, which receive 90% capital subsidy from the MNRE. A remote village or remote hamlet will be considered electrified if at least 10% of the households are provided with lighting facility. Under the RVE programme, the electrification process entails choosing the most adequate energy technologies through the identification of locally available energy resources. However, in the case where these solutions are proven unfeasible, and if the only means for electrification is through use of isolated lighting systems (such as solar PV), these should be taken up. However, the remote villages receiving them should not be declared electrified. In fact, where the population is scarce and remote, there is often no other renewable energy option but the installation of solar photovoltaic (SPV) home lighting systems. According to the MNRE, a total of 95%, a large share of remote census villages are provided with solar photovoltaic home lighting systems. However, these villages are not considered properly electrified until further solutions are implemented (Ministry of New and Renewable Energies, 2007).

Means of electrification

Under the RVE programme, solar photovoltaic home lighting systems, small hydropower plants, biomass gasification systems in conjunction with 100% producer gas engines or with dual-fuel engines using non-edible vegetable oils, non-edible vegetable oil-based engines, biogas engines, solar photovoltaic power plants are the most commonly used by the MNRE (Ministry of New and Renewable Energies, 2007). However, the vast majority, 95%, of remote census villages taken up for electrification under the programme are provided with SPV home lighting systems.

Many villagers in remote areas serviced under the RVE programme that are not recipients of grid-distributed power feel discriminated against when they are provided with what they feel is “second-class electricity”. Such complaints have been taken up by some political parties which have been exerting pressure for grid power to reach their constituents, as opposed to stand-alone systems. As a consequence, the list of villages to be electrified under the Remote Village Electrification (RVE) scheme is being shortened each year. In any case, such electrification is still considered an interim solution as, ultimately, the grid is expected to reach these regions.

Achievements of the RVE

The RVE programme of the MNRE covers remote un-electrified villages which are not covered under the RGGVY. In March 2009, the cumulative sanctions under the RVE programme had reached 9 355 villages and hamlets of which 5 410 have been successfully electrified. At the end of the 11th Plan, a total of 10 000 villages and hamlets should be covered. By March 2009, 2 600 villages and hamlets had been electrified (Ministry of New and Renewable Energies, 2009).

Table 24: Physical progress of implementation of the RVE at end March 2009

	Cumulative sanctions since inception of RVE	Completed
Villages	7425	4254 (57%)
Hamlets	1930	1156 (60%)

Source: Ministry of New and Renewable Energies (2009).

3.2.3 The Jawaharlal Nehru National Solar Mission (JNNSM)

The Jawaharlal Nehru National Solar Mission was launched on 23 November 2009 in a statement to Parliament by the Union Minister for New and Renewable Energies. This mission is part of the 2008 Indian National Action Plan on Climate Change (NAPCC) which seeks to reduce India's future reliance on non-renewable energy sources. Although the JNNSM has not been established to foster rural electrification *per se*, it does mention the use of solar energy as a means for rural electrification, thus helping the MNRE with its electrification goals. By the end of the 13th Five-Year Plan, in 2022, the JNNSM should have led to an installed capacity of 20 000 MW and the deployment of 20 million solar lighting systems in rural areas.

3.2.4 Description of the expected end-use of the electricity provided under RGGVY and RVE

Before 2004, rural electrification efforts were geared towards the electrification of villages and the energisation of irrigation pump sets. The main use of electricity in rural settings was for irrigation which allowed for the optimisation of crop yields and consequently grain production self-sufficiency. Previously suffering from food deficits, India became a food surplus country thanks to rural electrification efforts geared towards the agricultural sector. But this major economic benefit was captured mainly by already well-off farmers, leaving aside rural industries and trades which were not targeted by the electrification process (Bhattacharyya, 2006).

Under the RGGVY and the RVE, villages should be provided with electricity not only for domestic lighting, but also for productive end-uses, specifically targeting the development of economic activities within a given rural area. Electrification is expected to reverse the downward trend in agricultural growth which is plaguing rural India. Access to affordable and reliable electricity is expected to meet the energy requirements of the agricultural sector by energising irrigation pump sets as well as small and medium-sized industries, cold chains, health centres, schools, etc. Rural households are expected to play an active role in the region's economic development, which should lead to an increase in the revenue deriving from these activities. The final goal is the development of productive activities which will generate funds to cover the costs incurred by power supply, operation and maintenance of the systems.

Some states, such as Punjab and Tamil Nadu, have decided to provide free electricity to farmers to support their agriculture. In these states, other categories of customers, such as the domestic and industry sectors, have been burdened with heavy tax rates to support the deficits created by the provision of free electricity to agricultural consumers. According to the Associated Chamber of Commerce of India (Assocham), these losses reach each year around USD 400 000 (22 % of annual sales of power) in Punjab and USD 235 000 (6% of annual sales of power) in Tamil Nadu (Assocham, 2008). As a consequence of this free power provision, utilities in these states have been unable to supply reliable electricity to their industrial sector, thus reducing their competitiveness *vis à vis* other states, as noted by the Assocham. In addition, controversies over the allocation of free power to farmers have worsened because farmers are using their electric pump sets for other purposes than irrigation.

3.3 Institutional structures for rural electrification

3.3.1 India's power sector reforms, and policy reforms to promote electricity access

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The government of India has reformed the institutional and regulatory framework of its power sector. Reforms have ranged from unbundling of the State Electricity Boards (SEBs), increased involvement of the private sector in generation, transmission and distribution, to freer setting of electricity tariffs (Asian Development Bank, 2008). These reforms have led to furthering electrification efforts in rural areas. The “Power for All by 2012” initiative was launched by the central government in 2001. The objectives of the programme are to ensure “sufficient power to achieve a GDP growth rate of 8%, reliable and quality power, optimum power costs, commercial viability of the power industry as well as power for all” (Ministry of Power, 2009c). The Electricity Act of 2003 followed. It is currently the major piece of legislation covering generation, transmission and distribution of electricity in India which compels utilities to supply electricity to all (including in rural areas). Moreover, the National Electrification Policy (NEP) of 2005 (which states that the key objective of the power sector is to supply electricity to all areas, including rural areas), the Rural Electrification Policy of 2006 (provision of electricity to all households by 2009, quality and reliable power at reasonable rates and minimum lifeline consumption of 1 kWh per household per day as a merit good by 2012) and the National Tariff Policy of 2006, were all policies encouraging electrification efforts in rural India. These policies have improved the financial and institutional status of the state utilities, and of the state-level generation, transmission and distribution utilities. They have widened the state governments’ scope of action in rural electrification efforts. As a result of the power sector reform process, most state utilities have been unbundled and split into separate entities for generation, transmission and distribution of power.

3.3.2 The central and state governments’ responsibilities in rural electrification programmes

The launching of the RGGVY scheme in 2005 marked a turning point in India’s rural electrification efforts. In accord with the Electricity Act of 2003, the role of the central government became larger, as both central and state governments took over joint responsibility for rural electrification. State governments are now required to prepare rural electrification plans designed to assess in detail the means by which electricity is to be delivered – *i.e.* through grid extension or stand-alone systems – to the un-electrified households in their constituency. These plans also describe which available technologies will be considered, how compliance with environmental norms will be met, as well as more general information such as the number of un-electrified households in the target region and their distance from the grid. These plans are then co-ordinated between state governments, state utilities and other agencies by the Rural Electrification Corporation Limited (REC), a governmental body under the Ministry of Power that acts as the nodal agency for the RGGVY. State governments are also required to ensure revenue stability of their state utilities if electricity is provided at a tariff below what is set by the State Electricity Regulatory Commissions, to supply electricity to rural and urban households without interruption, to deploy franchisees and to appoint independent franchisees for monitoring the work. At the central level, the MoP develops rural electrification policies, monitors the programme’s progress, sanctions projects and releases funds for project implementation.

3.3.3 Institutional structure – implementing agencies

Under the RGGVY, state governments through their State Power Utilities (SPUs) are responsible for implementing the RGGVY in their territory. Central Public Sector Undertakings (PSUs)⁴³ can also assist the states in carrying out rural electrification projects through project formulation, planning and monitoring, and the provision of goods and services. The Rural Electrification Corporation (REC) has therefore entered into a Memorandum of Understanding (MoU) with some PSUs, namely NTPC, Powergrid, NHPC and DVC to make available management expertise and capabilities to the states that wish to work with them. The REC, as the nodal agency of the RGGVY, not only acts as a lending agency, but also co-ordinates activities between the MoP and the MNRE, sets the framework for project implementation and monitors and evaluates projects to ensure their timely implementation.

Under the Remote Village Electrification programme, state nodal agencies are responsible for the implementation of rural electrification projects.

3.3.4 Institutional structure – lending agencies

Under the RGGVY, the MoP grants 90% of the cost of rural electrification projects. States are supposed to cover the remaining 10% of the cost either from their own funds or through loans from the REC or other institutions.

The three main financial agencies in the power sector are the Rural Electrification Corporation Ltd. (REC), the Power Finance Corporation (PFC) and the Indian Renewable Energy Development Agency (IREDA). Only the REC is authorised to act as the nodal agency or lending agency for rural electrification projects under RGGVY. IREDA supports a much wider range of projects in rural areas, including minor-scale rural electrification schemes through renewable energy applications focusing mainly on biomass and solar PV lighting systems. The PFC lends only to major generation and transmission projects, but not to rural electrification programmes.

The Rural Electrification Corporation Ltd. was created in 1969 as a wholly government-owned enterprise or nodal agency exclusively responsible for the implementation of rural electrification schemes, through long-term financing and promotion of rural electrification projects in India. Through the development of the power infrastructure in rural India, it has participated in the development of the agricultural sector. Since its creation, the REC is India's main financing institution for rural electrification and benefits from strong support from the government of India. Today, although the REC continues to foster the development of rural electrification in India, it also finances other segments of the power sector. The REC administers grants and provides loan assistance to the State Electricity Boards/State Power Utilities for investment in rural electrification schemes through its head office and 17 field offices. These field offices are essential to the work of the REC as they collaborate with the state governments in which they are settled to help them formulate various schemes and loan sanctions. On the basis of the proposals made by the states, the REC divides responsibilities for electrification between the Ministry of Power and the Ministry of New and Renewable Energies. In this respect, the REC decides which villages or hamlets will be considered remote (where grid connection is either not feasible or not cost-effective) and therefore which will be electrified through either the RGGVY or the Remote Village Renewable Energy Programme (RVREP).

⁴³ A Public Sector Undertaking (PSU) is a government-owned corporation in which the government (whether central, state or territorial governments, or all of them) own more than 51% of the company.

The Indian Renewable Energy Development Agency (IREDA) was established in 1987 under the administrative control of the MNRE for the promotion of financial assistance in favour of renewable energy and energy efficiency projects. One of the main objectives of IREDA is to act as a fund for the financing and promotion of new and renewable energy sources and to assist in their rapid commercialisation. In this respect, IREDA has found its role in providing financial support for the use of renewable energies in the electrification of remote villages under the RVE programme of the MNRE.

3.3.5 Institutional structure – monitoring and quality check

In order to keep up the pace of electrification, the MoP has asked the states to form state-level Coordination Committees. These committees are required to meet regularly in order to resolve any potential issue that could slow the pace of project development. States are also required to form District Committees with representatives from various stakeholders, including elected members and local communities. These District Committees help in the co-ordination and review of the coverage of electrification within the district. The Ministry of Power has noted that where these Committees were active and met regularly, progress in rural electrification projects had improved (Press Information Bureau, 2009).

In addition, a milestone-based monitoring mechanism has been introduced to monitor the progress of RGGVY projects from project sanction up to project completion. A web-based monitoring system has also been introduced which works at village level. Through this monitoring system, implementing agencies are supposed to provide all the data relating to activities carried out at village level, the result of quality inspections, the state of fund utilisation, the state of village electrification, etc.

3.3.6 Institutional structure – financial recovery process

Electricity connections are free for consumers below the poverty line (BPL). To facilitate recovery of customer payments from those above the poverty line, the RGGVY has ordered the creation and deployment of franchisees for the development/operation of “a generation and distribution system within an identified contiguous area for a prescribed duration and collect revenues directly from rural consumers” (Ministry of Power, 2009d). Such entities are meant to ensure stable revenue flows and services to electricity consumers, by reducing commercial losses through facilitation of efficient billing and revenue collection. All franchisees have common activities: they must purchase bulk power, and ensure routine operation and maintenance of the distribution infrastructure. To ensure the sustained efficiency of the franchisees, the RGGVY applies a process by which franchisees are to be reviewed in case they fail to honour their contractual obligations with the state government, such as, for instance, if they fail to collect the revenues from electricity consumers, or fail to reimburse the cost of electricity. For this reason a termination clause is included in the contractual obligations of the franchisee and the state government, if one or the other fails to comply. Moreover, the Press Information Bureau (2009) noted that franchisees are contributing to the employment of rural inhabitants. In August 2009, franchisees had been established in a total of 99 643 villages.

3.4 Costs, incentives and tariffs

3.4.1 Costs of the RGGVY

The total costs of schemes under RGGVY have recently been estimated to reach USD 11.3 billion, one-tenth of which is allocated to decentralised distributed generation (DDG). This includes projects under both 10th and 11th Plans to be completed by March 2012. Total grants allocated by the central government are expected to amount to USD 10.2 billion (INR 459 billion).⁴⁴

Under the RGGVY scheme, 90% of the project costs is funded by the Ministry of Power. The state governments fund the remaining 10% through either long-term loans from the REC or other financial institutions, or out of their own budgets. However, government subsidies under the RGGVY are expected to be allocated only once to finance the least-cost village electrification projects. At the same time, rural households are expected to play an active role in the region's economic development, which should lead to an increase in the revenue arising from productive activities. The purpose is that the development of productive activities will generate enough revenues to cover the costs incurred in power supply, operation and maintenance, and will also ensure that no additional government money will be needed to fund the replacement in the future of any part of the system. In the event the RGGVY scheme is not implemented in a satisfactory way, capital subsidies will then be converted into interest-bearing loans as an incentive to correct the implementation of the scheme. Up to 1% of the total subsidy will be allocated to research and technology development, capacity building and, *inter alia*, the financing of pilot studies and complementary projects under the rural electrification scheme.

For un-electrified households below the poverty line (BPL), electrification projects are 100% financed by capital subsidies up to approximately USD 45 (INR 2 200) per rural household. Table 25 shows the cost norms defined by the Ministry of Power for village electrification.

Table 25: Cost norms for village electrification

Electrification of un-electrified villages	Cost in INR	Cost in USD
a. In normal terrain	13 000	27
b. In hilly, tribal, desert areas	18 000	37
Intensive electrification of already electrified villages		
a. In normal terrain	4 000	82
b. In hilly, tribal, desert areas	6 000	123
Cost of electricity connection per BPL household	2 200	45

Source: Ministry of Power (2008).

3.4.2 Costs of the RVE programme

The total cost for the implementation of the Remote Village Electrification programme (which focuses on those remote villages that are not targeted by the RGGVY), is estimated to amount to INR 17 750 million (USD 354 million) over the 11th Five-Year Plan. Similarly to the RGGVY, Central

⁴⁴ Cost data were provided by RK Sachdev.

Financial Assistance (CFA) of the MNRE grants a subsidy covering up to 90% of the cost of the project implementation, up to a predefined maximum of INR 18 000 (USD 360) per household (Ministry of Power, 2008). In line with current practice under the RGGVY, the MNRE also offers a 100% capital subsidy for BPL household connections.

3.4.3 Framework conditions and business incentives

Lending agencies

To encourage banks and other lending institutions to consider rural electrification initiatives favourably, the government of India has been working with the National Bank for Agriculture and Rural Development (NABARD) and the Reserve Bank of India to facilitate norms, guidelines and limits for capital costs.

Business incentives

The Electricity Act of 2003 has contributed to increase competition in the electricity sector. This act has given private investors access to all power sector operations. As a consequence, state governments encourage the private sector to invest in rural electrification projects. To do so, many state governments have established administrative mechanisms to facilitate the process of approval and clearance for the setting-up of small and medium-sized industries. Those specifically targeted are industries that seek to use local resources for decentralised generation projects and stand-alone systems. In this respect, a “special enabling dispensation” is considered for stand-alone systems of up to 1 MW which use locally available resources and are based on proven cost-effective technologies. Such projects will receive immediate approval for the following issues:

- “Change of land-use area as long as norms are satisfied;
- Pollution clearance if the technology is proven to be within norms;
- Safety clearances on the basis of self-certification conveyed to concerned authorities (such certification making the developer fully liable for any infraction to safety regulations).” (Ministry of Power, 2005)

State governments are also responsible for setting up institutional arrangements for any maintenance service or technical support for renewable energy systems.

After sales approach (spare parts, maintenance)

To make sure that an after sales approach is integrated in the design of the project before its implementation, the RGGVY stipulates that any project seeking financial support must incorporate plans for regular maintenance and upgrading. Moreover, the projects should demonstrate that measures will be taken to minimise technical and commercial losses.

To ensure project sustainability under the RVE, annual maintenance contracts (AMC) with a minimum 10-year duration warranty must include the replacement of parts or components such as batteries, electronics, lamps, bulbs, etc. These AMCs guarantee efficient after-sales support. They will be further detailed below.

3.4.4 Customer tariff setting

A major problem in India’s electricity market is that electricity is often not paid for. Either electricity is not billed for or when it is, it is not paid. Also, electricity theft is rampant, with annual losses amounting to USD 4.5 billion, roughly 1.5% of GDP (World Bank, 2004). This loss of revenues

amounts to a mass of implicit government subsidy, as noted in *Electricity in India* (IEA, 2002b), and undermines the efficiency and long-term sustainability of the supply system, and in the long run does not benefit electricity consumers.

Electricity tariffs are also a sensitive issue in India. Below poverty line households will be provided with free electricity connections. By 2012 these electricity connections will be financed with government capital up to INR 2 200 (approximately USD 45) per household in all rural habitations. Those households above the poverty line will pay for their connection at prescribed connection charges and no government subsidy will be released for this purpose. In the case of decentralised systems, capital subsidies should not give rise to too many differences between the price that remote villages powered by DDG systems will pay for electricity, and the price paid by villages connected to the grid. But rural electricity tariffs are often lower than the average cost of electricity supply, and state governments are responsible for making budgetary provisions for subsidised electricity supply.

3.5 Country-specific challenges and how they were addressed

Franchisees and ownership

The creation of franchisees for the management of local power distribution in rural settings is a requirement under the RGGVY. Because these structures reduce commercial losses through more efficient billing and revenue collection, they ensure stable delivery of electricity. Franchisees can be different legal entities, such as non-governmental organisations, co-operatives or individual entrepreneurs. While their exact nature or structure may vary from one franchisee to another, they all have common activities: they must purchase bulk power, and see to routine operation and maintenance of the distribution infrastructure. Franchisees are granted a distribution licence through a competitive bidding process. Those offering the cheapest bulk supply tariff will be allowed to operate under a contract with the state governments. Franchisees are particularly effective in the management of electricity provision and recovery as they are in close contact with the targeted communities, and this has led to a stronger sense of ownership of the electrification process.

Management and reduction of losses

Illegal hooking is still rampant in India, particularly in the rural villages, which are by definition difficult to control. Through the 2003 Electricity Act, the Indian government made a fundamental amendment to the Electricity Act of 1910, rendering theft of electricity a heavily penalised criminal offence. Moreover, under the RGGVY, to prevent illegal hooking and so reduce commercial, transmission and distribution losses, high-voltage distribution systems (HVDS) are being installed. Through HVDS, the voltage profile is also improved and electricity supply is more reliable. Franchisees also play an important role in reducing electricity theft, since they are responsible for recovering payments and are in close contact with the targeted communities.

Corruption and mismanagement of funds have also been plaguing the system, which has caused the RGGVY to progress unevenly in the states. To balance this, the release of funds by the REC under the RGGVY scheme is now linked to the achievement of predetermined milestones, leading to more control of the system. Also the electronic transfer of funds is used right up to the contractor level to counter losses from fund mismanagement.

Participation of local communities for operation and maintenance

Under the Remote Village Electrification (RVE) programme of the Ministry of New and Renewable Energies, effective operation, maintenance and sustainability of the projects is the responsibility of

the state governments. The participation of the local community is sought at the inception of the project and efforts are made to ensure at least 15 years of operation and maintenance. To this end, state governments aim to organise the training of local youth and to set up village committees. However, as renewable energy systems develop rapidly, there is often an insufficient number of trained workers who know how to maintain and operate systems such as, for instance, solar PV. A more systematic approach to training would ensure better maintenance of the installed systems (Baker and McKenzie, 2008).

Progress monitoring and maintenance

A Three-Tier Quality Monitoring Mechanism (TTQM) for the projects under the RGGVY has been put in place (Ministry of Power, 2009e). For the first tier, a project implementing agency (PIA) works with a third-party inspection agency to ascertain that all the materials used in the projects and workmanship are conform to specifications. The REC is responsible for the second tier and will inspect works and materials. It will also include quality checks of materials at the pre-shipment stage. In the third tier, independent evaluators will be contracted by the Ministry of Power for random evaluations (1% of villages) of the supply and construction of the projects. These independent evaluators will report back to the REC or to the responsible supervisors in the second tier, and the REC will make sure that the negative reports are followed up on. This monitoring system has been set up to ensure that projects are properly implemented and to contribute to their efficiency and long-term sustainability.

The RVE also encourages the setting-up of annual maintenance contracts (AMC) with a minimum 10-year warranty which includes the replacement of parts or components such as batteries, electronics, lamps, bulbs, etc. to secure proper and sustained energy supply services. If some projects are not covered by the 10-year AMC, sustainability is ensured through revenue collection from electricity consumers, which should cover operational expenses. After the AMCs expire, revenues could also be used to cover maintenance and repair expenses or replacement of spare parts and defective components.

Availability and sufficiency of power supply

Under the RGGVY, state governments are responsible for providing adequate supply of electricity with hours of supply being equal for rural and urban dwellers. States are responsible for ensuring that at least 6 to 8 hours/day of electricity are supplied in rural areas.

Implementation of other policies

Energy efficiency clauses are one of the keys to the success of a rural electrification policy. The government of India has made sure that productive processes are efficient or less energy-intensive than standard ones. This applies particularly to the agricultural sector, which has been encouraged to use economically viable irrigation pump sets and other energy-efficient farming equipment. According to the Integrated Energy Policy (IEP), correct implementation of demand-side management policies could save up to an estimated 15% of electricity consumption. The legal framework for this IEP was provided by the Indian Energy Conservation Act 2001 the aim of which was to accelerate energy efficiency in India. Since 2002, the Bureau of Energy Efficiency (BEE) has been the governmental agency responsible for implementing the Energy Conservation Act. Some of the major initiatives led by the BEE include:

- Bachat Lamp Yojana: Promotion of energy-efficient and high-quality compact fluorescent lamps (CFLs) to replace incandescent bulbs in households;
- Standards & Labelling Scheme: Targeting high energy end-use equipments and appliances for minimum energy performance standards;

- The Energy Conservation Building Code (ECBC): Setting minimum energy performance standards for new commercial buildings; and
- Agricultural and Municipal DSM: Demand-side management for the agricultural and municipal sectors with special targets on the replacement of inefficient pump sets, street lighting, etc.

During the 10th Plan, only 877 MW⁴⁵ of electricity was effectively saved through energy conservation efforts, while the energy efficiency target for the 11th Plan period is close to 10 000 MW. The RGGVY also planned to communicate massively through the media in rural areas in order to promote energy efficiency, and sound management of the local electricity distribution system.

3.6 General challenges and conclusion

During the 10th Plan, some basic problems hindered the successful implementation of rural electrification programmes in India. First, India's rural distribution system is essentially low-density with high technical and commercial losses leading to a high delivery cost. Therefore, utilities which supplied power to rural areas usually considered such supply as commercially unviable, mainly because of the high fixed and variable costs and "unsustainable commercial arrangements" (Ministry of Power, 2005-2006). For this reason, utilities were generally not inclined to take up rural electrification projects through funds arranged on a commercial loan basis, for fear of further deterioration in their financial health. During the 10th Five-Year Plan (FYP) there was only limited financial outlay for the implementation of the RGGVY, and some cases of government corruption and mismanagement of funds have plagued the system. Because of the lack of political will as well as multi-institutional involvement and inadequate financial resources for the establishment of basic transmission and distribution infrastructure in rural areas, resources were too scarce to allow for the complete implementation of the RGGVY scheme during the 10th Plan.

Implementation delays under the RGGVY have also been occurring at the state level. Some state governments have been slow in awarding contracts owing to their lack of preparedness for implementing projects on a turnkey basis; others have been slow in acquiring land for the 33/11 kV sub-stations, others in providing authenticated lists of BPL households (in some states the number of BPL households turned out to be greater than foreseen), and still others in providing necessary forestry clearance. Sometimes, there was no monitoring because state-level committee meetings had not been convened. Difficult terrain and floods in some states have added to the delay in implementation of projects. Overall, there has been long-standing unavailability of sub-transmission systems, of adequate quantities of material and equipment, particularly poles to be procured locally in the project areas, and unavailability of adequately skilled manpower. Finally, franchisee systems were slow to be put in place, which led to theft of materials and electricity as well as the non-payment of bills in some states (Ministry of Power, 2009a).

With the 11th Plan, there was strong political commitment to achieving the goal of 100% sustainable village electrification. The apolitical implementation and monitoring of the projects has strengthened the programme. But today, India is facing real constraints to widespread electrification. India currently has insufficient electricity generating capacity, which is seriously hindering the implementation of rural electrification programmes and undermining their viability. Whether the targeted additional capacity of 78 700 MW over the 11th Five-Year Plan will indeed be reached and be sufficient to cover the needs for the full electrification of all villages and

⁴⁵ Data reported by participating units in the National Energy Conservation Awards.

households, remains to be seen. A minimum of 20 000 MW of power is estimated to be required to meet the needs of the RGGVY alone (Vidyasagar, 2007). The productive use of electricity at the household level would support load development and secure the viability of the electrification efforts. Without a defined strategy for encouraging productive use of electricity at the household level, the viability of the RGGVY scheme may be undermined. Moreover, the economic sustainability of the electrification efforts is also undermined by the lack of systematic evaluation of how operations' costs can be recovered. Failure to assess the real potential for cost recovery may lead to the need for long term provision of government grants, way beyond the end of the programme (Vidyasagar, 2007). Equally critical is the issue of the effective maintenance and proper upgrading of the rural electricity infrastructure as well as its economic sustainability, which will depend on the states and utilities' long-term involvement. Finally, to reach the targets set under the RGGVY in 2012, it is estimated that state utilities would have to "gear up their effort by ten times" (Vidyasagar, 2007) and provide substantial financial commitment.

4 South Africa

Since 2000, the government of South Africa has been seeking to provide universal access to basic services, including electricity. In 2009 South Africa achieved 75% electrification with 88% urban and 55% rural populations who gained access to electricity services (IEA, 2009b). South Africa's electrification has been achieved mainly through grid extension. In the future, more renewable sources may facilitate further electrification if barriers to their widespread use are overcome. South Africa's energy sector, electrification efforts and remaining challenges are described below.

4.1 Introduction and country description

Rural electrification in South Africa is part and parcel of the transformation of South African society. Since the first free election in 1994, all South African policies – including those of electricity provision – contain an element of change. The objective is to eradicate historical inequalities based on ethnicity. While a large proportion of poor people live in rural areas, there are also very many of them in urban areas. The urban poor live predominantly in townships or in informal settlements. During the Apartheid years, Black, Coloured and Asian people were not allowed to live in the same areas as the white part of the population. Consequently each city, town and village had established areas with good service delivery, and areas with poor or no service delivery. To date, there are still areas without basic services such as water, sanitation and access to electricity. This chapter focuses on the experience with electrification of the poor who live mainly, but far from exclusively, in the rural areas.

Figure 9: Map of South Africa



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Source: www.places.co.za.

The Republic of South Africa occupies the southern tip of Africa. It is the 32nd-largest country in the world in terms of size, totalling an area of 1 219 914 km², with a long coastline that stretches

2 798 kilometres and across two oceans (South Atlantic and Indian Oceans) (CIA, 2009). Although South Africa is classified as semi-arid, there is considerable variation in climate as well as topography. The climatic zones vary, from the extreme desert in the farthest north-west to the lush subtropical climate in the east along the Mozambique border and the Indian Ocean. The terrain consists of a vast interior plateau rimmed by rugged hills and narrow coastal plains.

GDP in purchasing power parity has shown a steady growth over the past years and is estimated to be USD 495 billion in 2009 (International Monetary Fund, 2009). South Africa has one of the highest rates of income inequality in the world.

The transformation of the society is based on the understanding that economic changes require active strategic intervention from the State. This encompasses continued state ownership of entities in the energy and transport sectors as well as acting as a catalyst towards the broader development of the economy. The private sector is, however, expected to play an active and integral role in the economy. Moreover, affirmative action policies such as the Broad-based Black Economic Empowerment (BBBEE), which obliges companies to comply with a broad range of quotas (ownership, management positions, general staff, etc.) for formally disadvantaged groups, are furthering the transformation of the society.

According to the last census conducted in 2001, total population had then reached 44.8 million. By end-2008 total population was estimated to have increased to over 48 million, including some 4 million immigrants mainly from other African countries (Statistics South Africa, 2009). This gives a population density of 39 per km², which is low, ranking 170th in the world.

Table 26: Mid-year 2007 population count estimate and ethnic distribution

	Total number	% of the population
African	38 079 900	79.6
Coloured ⁴⁶	4 245 000	8.9
Asian	1 173 700	2.5
White	4 352 100	9.1
Total	47 850 700	

Source: Statistics South Africa (2008a).

South Africa is known for its diversity in cultures, languages and religious beliefs. Eleven official languages are recognised. English is the most commonly spoken language in official and commercial public life. Yet English is only the fifth most-spoken home language (South Africa Info, 2008). The population is mostly composed of Africans, Coloured and Asians (see Table 26), who are still often living in different geographical zones from the Whites. HIV/AIDS prevalence was estimated at approximately 11% in 2007 (Human Sciences Research Council, 2009), and life expectancy had then dropped to 49 years for men and 52 years for women. Without HIV/AIDS it is estimated that life expectancy would be at least 10 years longer for both (Avert, 2009).

Energy contributes about 15% of South Africa's GDP. The country's supply and production system is well developed, but has recently been facing strong electricity supply crises as well as inefficiencies

⁴⁶ The term Coloured is used for the people of mixed race.

in distribution (grid problems and responsibilities scattered over 180 municipalities) that have not yet been successfully tackled.

Table 27: South African total energy supply in 2006

TJ (2006)	Coal	Crude	Petroleum products	Gas	Nuclear	Hydro	Other incl. RE	Elec.	Total
RSA production	5 788 410	308 603		108 166	109 374	9 894	430427		6 754 826
Import	57 428	926 356	135 263	52 201				38 246	1 209 495
Export	-1 926 941	-20 838	-125 872					-48 920	-2 122 572
Stock	-197 740		-107 937						305 678
Prime supply	3 721 156	1 214 121	-98 547	160 317	109 374	9 894	430 427	-10 674	5 536 070

RE: renewable energies

Note: Before May 2009, the Department cited in the source below was responsible for the energy sector. It was renamed Department of Energy (DoE) after the general elections in April 2009 and the restructuring of government departments.

Source: Department of Minerals and Energy (2006).

Most of South Africa's energy supply comes from coal (see Table 27). South Africa ranks fourth in the world in the production of hard coal, and is the fifth-largest exporter of hard coal in the world (IEA, 2008). In 2007, South Africa's electricity generation reached 266 Twh (IEA, 2009a). South Africa has an installed capacity of 43 650 MW (Platts, 2008) which represents close to 34.5% of the African continent's total installed capacity. Electricity is produced mainly from coal (94%). Eskom – the national power utility – generates 97% of the electricity. Around 55% of the distribution is managed by Eskom and 45% by the municipalities (National Energy Regulator South Africa, 2006a). Since 1994 no new generation capacity has been built. Because of strong economic growth, rapid industrialisation and a massive electrification programme, Eskom's surplus capacity has been reduced to below safe production levels. In January 2008, massive power outages occurred nationwide. South Africa has since embarked on aggressive demand-side management (DSM), energy efficiency, as well as planning new generating capacity programmes. South Africa has one of the lowest electricity tariffs in the world with an average selling price at around USD 0.027 per kWh.

In 2000 the South African government declared that everybody should have access to basic services, including electricity and water. Access to modern energy and water has become a social right that must be addressed at national, provincial and municipality levels. The electrification rate of South Africa is 75% in 2009. (Electrification is registered as electrification of households and not as the number of people). But there is a great variation in the electrification rate between the provinces, with Eastern Cape being mainly a rural area and having the lowest electrification rate (60%) and Western Cape having the highest rate (86%) as shown in Table 28.

Table 28: Electrification rate in South Africa in 2009

Province	Number of households	% electrified	% non-electrified
Eastern Cape	1 667 435	60	40
Limpopo	1 250 716	74	26
Kwa-Zulu-Natal	2 405 165	66	34
Gauteng	3 127 991	76	24
Free State	823 972	75	25
Northern Cape	272 958	82	18
Mpumalanga	879 082	74	26
Western Cape	1 333 886	86	14
North West	914 070	78	22
Total	12 675 275	75	25

Source: Department of Energy (2009j).

Moreover, while 75% of South Africans have access to electricity services, according to the *World Energy Outlook 2009* (IEA, 2009b) 88% of urban dwellers and 55% of rural dwellers are connected.

4.2 Institutional structures for rural electrification

The governance of the electricity sector is the responsibility of the Department of Energy (DoE). Before 1994 Eskom was responsible for the electrification of the country. Eskom held a state-supported monopoly and would electrify an area upon instruction from the government or connect a consumer if the consumer would pay. There was systematic neglect of full service delivery to the Coloured, Black and Asian communities. In 1994, after the first free election was held, it was estimated that approximately 6 million households (Department of Energy, 2009b) were without electricity. The backlog in electrification was largely race-based and hence electrification became part of the national priorities to redress the errors and inequalities of the past.

In 1994, Parliament approved a plan to ensure equal access to basic services for all South Africans. The National Energy Regulator⁴⁷ was given the task to develop and oversee the implementation of the Integrated National Electrification Programme (INEP). Eskom was tasked by NERSA to undertake the implementation through the use of contractors as part of any other Eskom business. In 2001 it was decided that the DoE would be responsible for the implementation and oversight of the electrification programme.

Municipalities are now responsible for reticulation and distribution of electricity to households as well as to small businesses. Eskom maintains direct supply of electricity to larger industries. In 2008,

⁴⁷ Before 2005, the National Energy Regulator South Africa (NERSA) was called the National Energy Regulator (NER).

Eskom generated approximately 97% of the electricity and distributed some 55% to end-consumers while the rest was sold to the municipalities, that in turn distributed it to the end-consumers (National Energy Regulator South Africa, 2006b).

In 2001 the DoE mandated that not only Eskom but also registered municipalities could receive national funding to roll out the national electrification programme. DoE is responsible for monitoring their actual performance and ensuring that corrective measures are taken in case of poor or non-performance. Such poor or non-performance occurs in municipalities that are licensed but not yet experienced in rolling out grid connections. For this reason, DoE has occasionally provided one-off capacity building support to such municipalities.

The electrification programme benefits from a special allocation from National Treasury and not funded through cross-subsidies. Once households are electrified, consumers are billed by the municipalities. The main funding of the National Electrification Programme is through the National Budget. External donor agencies, in particular the German KfW, support the electrification of schools and clinics. Also NORAD, the Norwegian agency for development co-operation, provides support in the form of capacity building, for example to monitor sale and management of electricity, also at the municipal level.

In remote rural areas, where the lowest-capacity grid system cannot be supplied within the capital expenditure limit and outside the 3-year grid electrification plan, provision is made for non-grid electrification through solar home systems (SHS) (Department of Energy, 2009c). An amount equivalent to the lower end of average electrification costs is fully subsidised by the government to cover part of the capital costs of non-grid electrification. Rural end-users will purchase non-grid electricity from the service provider who will, among other things, provide maintenance for the SHS. Since these cannot meet the cooking/thermal needs of households, one of the requirements of the DoE is that the suppliers of non-grid technologies augment their services by selling thermal fuels such as paraffin and liquefied petroleum gas (LPG). The installation of SHS must be such that the maximum densification of the installed base is achieved in a specific area. The service provider, who holds a monopoly for servicing an area, must make sure that universal access is achieved in a village identified as a non-grid area. In early 1999, the DoE issued a call for proposals for non-grid rural electrification. Of the 28 responses received, six consortia were selected through an open bidding process to participate in the first phase of a programme to provide non-grid electricity services to identified areas. The six private companies are Summer Sun Trading (Pty) Ltd; Shine The Way cc; ILITHA Cooperative; Electricité de France; Total Fina Elf Group; Nuon RAPS Utility (Pty) Ltd; Solar Vision (Pty) Ltd, and a EUR 50 million support from KfW.

The electrification programme deadline has been moved from 2012 to 2014 by which time the backlog in electrification should be completed.

4.3 Description of current electrification programmes and objectives

The Integrated National Electrification Programme (INEP) consists of a grid-connection programme, a non-grid programme, household connections, electrification of schools and of all registered clinics. The main focus is the grid connection, and non-grid connection is only used if there are no other feasible options to extend the grid within a foreseeable future.

Before 1994, South Africa only focused on electrification of urban areas. In 1993, some 30% of households were electrified. Since 1994, there has been a fundamental shift towards electrifying all

households, including those living in rural areas. The grid electrification rate has since then increased from 30% in 1993 to 73% in March 2008 (Department of Minerals and Energy, 2008b), that is 4.5 million more households (Table 29). The increase in coverage is the result of both extending the grid to new communities such as rural areas and connecting the unconnected in already electrified areas. The electrification rates vary depending on the complexities of grid extension and population density, with the relatively higher-density areas having been electrified first.

Table 29: National grid electrification of households by Eskom and municipalities 1994-2008

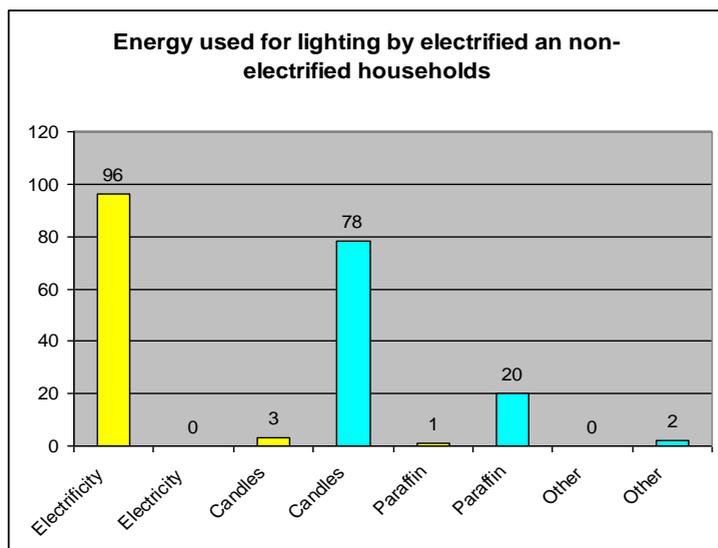
	1994/2001	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Number of households	3 036 726	338 572	278 762	312 187	213 127	241 703	105 625	221 439	87 221

Source: IEA analysis.

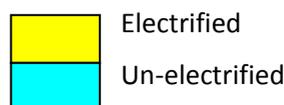
In 2009, 3.4 million households still remain to be electrified in South Africa (Mketsi, 2009) of which about half (1.7 million) live in informal settlements. It is a priority of the South African government that the problems faced by the 1.7 million households living in informal settlements be resolved by their municipal councils, before electrification can be implemented. The areas must either be formalised, or the households must move to other formalised human settlements before they can benefit from the national electrification programme. This is because it is not cost-effective to electrify an unstable dwelling that may be demolished or destroyed by any climatic occurrence. For the 1.7 million households in formal settlements, a plan, including budget, is in place to ensure connection before 2014. A major challenge in the household electrification programme is the actual housing backlog, for which a special policy has been drawn up (Department of Energy, 2009d).

The INEP includes special plans for electrification of all clinics and all schools to catch up with all remaining backlogs. Schools and clinics can be electrified by using funds from the INEP or through donor funding. Adherence to all agreed technical standards is required, whether for grid or non-grid connections. By 2007, full electrification of all registered health clinics in the country had been successfully completed one year ahead of schedule. By 2007, 700 schools had been electrified but the programme has been behind schedule, largely because of poor information about the number of schools to be dealt with in the smaller municipalities (Department of Energy, 2009b; Seshotlho, 2009).

Over the past years, the DoE has undertaken systematic monitoring of the INEP's socio-economic impact (Department of Energy, 2009j). Monitoring is carried out among newly electrified consumers. (In the longer run it will be interesting to undertake broader economic assessments to locate possible long-term changes.) This monitoring exercise has revealed that the majority, 96%, of electrified households use electricity for lighting and TV; 63% use electricity also for cooking; a large proportion of the population, 34%, use electricity for heating. In comparison, the majority of un-electrified households use candles for lighting, use wood or paraffin for cooking and wood for heating (see following charts).



Households

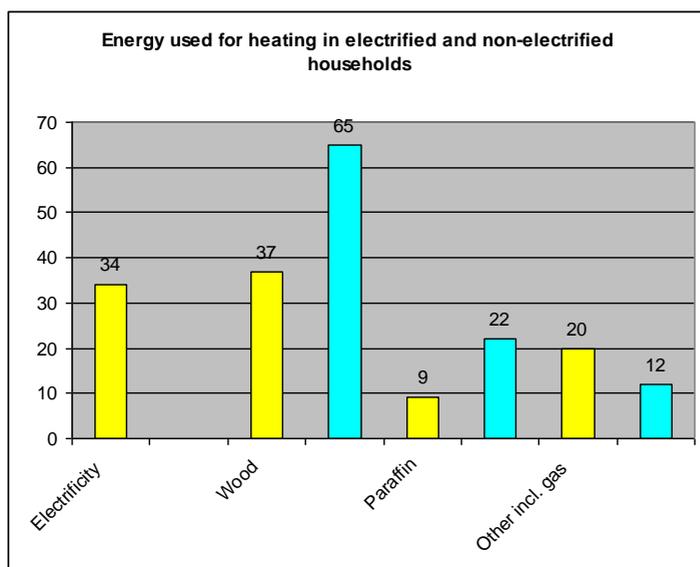
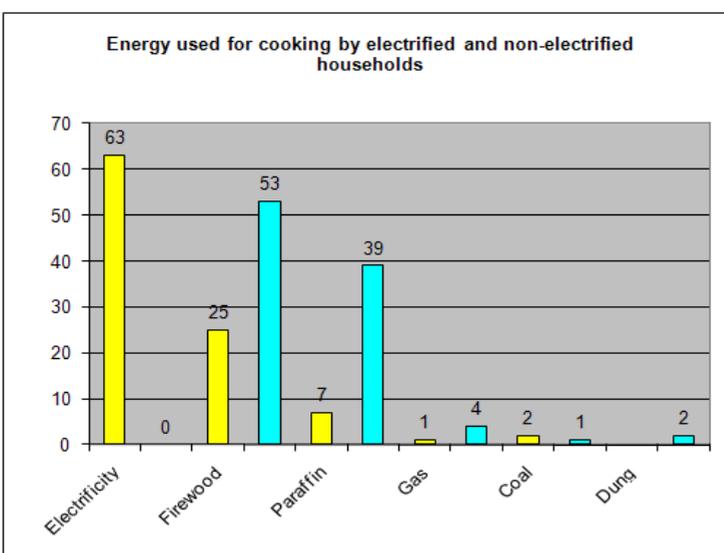


According to the Socio-Economic Survey undertaken by the DoE in 2009 among newly electrified households.

Households:

87% of households interviewed in the survey (total 2 3830 interviewed) indicated that they have benefited from electrification. The most frequent benefit (71%) was that electrification “makes life easier”. The second most cited benefit (cited by 55% of people interviewed) was “use of electrical appliances”, closely followed by “save time” (which 54% of people interviewed cited as a benefit of electrification). Finally, 22% mentioned that they “saved money” and 9% had opened small businesses.

Only 10% of the households indicated that electrification had contributed positively to their income generation. Of those 10% cooking was the most popular profitable activity, followed by refrigeration (used for conserving and selling soft drinks, and meat). A few households earned income from baking or hair dressing, while only 1% of the 10% earned income through woodwork using electricity.



Communities:

62% of households believed that the electrification process had benefited their community. The community benefits cited were the ability to start small businesses (65%), improved security (42%) and better use of schools. These positive perceptions vary from 90% (Northern Cape) in some regions to 45% in other regions (KZN)

4.4 Costs, incentives and tariffs

4.4.1 Grid electrification

Page | 88 The INEP is largely financed from the National Budget, an average of USD 160 million annually since 2003 (see Table 30).

Table 30: National electrification actual expenditures 2003-2008 (in ZAR)

	2003/04	2004/05	2005/06	2006/07	2007/08
Schools/clinics ¹	1 073 000	1 090 000	477 000	0	0
Housing (Eskom)	764 524 000	885 752 000	643 643 000	764 920 000	700 944 000
Housing (municipalities)	0	180 836 000	236 277 000	342 110 000	0
Household connection	156 177 000	180 515 000	106 993 000	0	0
Non-grid electrification	0	22 416 000	79 800 000	84 000 000	84,000,000
Total in ZAR	921 774 000	1 270 609 000	1 067 190,000	1 191 030 000	784 944 000
28 Feb exchange rate (1)	0.1509	0.1728	0.1629	0.1372	0.1369
Estimation in USD	139 095 697	219 561 235	173 845 251	163 409 316	107 458 834

Exchange rate for the South African rand (ZAR) prevailing on 28 February 2009 at www.gocurrency.com

Note: All data are verified data from the National Treasury expenditure for local governments, including Eskom provisions at the local municipality level which are provided by the DoE. Data for years 2006/07 and 2007/08 for the non-grid programme are estimates by the DoE Budget Vote.

Source: IEA analysis.

The costs of non-grid electrification, generally viewed as a temporary solution, are less than 10% of full electrification costs. The ambition is to achieve a national grid-based supply, and the plan is to complete the full-scale national electrification by 2014. However, the currently approved budget cycle covers the period up to March 2008-2012 (see Table 31).

As can be seen from Table 31, future expenditures are expected to increase, partly because of higher costs and partly because the number of connection activities has increased. The costs per connection vary greatly from province to province and from year to year and the differences in costs are largely caused by infrastructure specifics (Table 32).

Adherence to all agreed technical standards is required, whether electrification takes place through grid connection or through non-grid specifications. Specific standards adopted as national standards under the auspices of the South African Bureau of Standards exist for the full electrification installation.

Table 31: National budget electrification expenditures in ZAR (2008⁴⁸-2012)

	2008/2009	2009/2010	2010/2011	2011/2012
Schools/clinics ¹				
Household (Eskom)	1 240 758 000	1 570 770 000	1 649 309 000	1 748 268 000
Household (Municipalities)	595 637 000	897 008 000	950 828 000	1 007 878 000
Household connection ²	0	0	0	0
Non-grid electrification	84 000 000	84 000 000	88 200 000	93 492 000
Total in ZAR	1 920 395 000	2 551 778 000	2 688 337 000	2 849 638 000
28 Feb exchange rate	0.0987	0.0987	0.0987	0.0987
Total estimated in USD	189 542 987	251 860 489	265 338 862	281 259 271

1. The school electrification budget is not included as it was supposed to have been completed at the time this budget was being prepared.

2. The household connection subsidy is not specified in the budget forecasts as this is largely a choice to be decided by the municipalities.

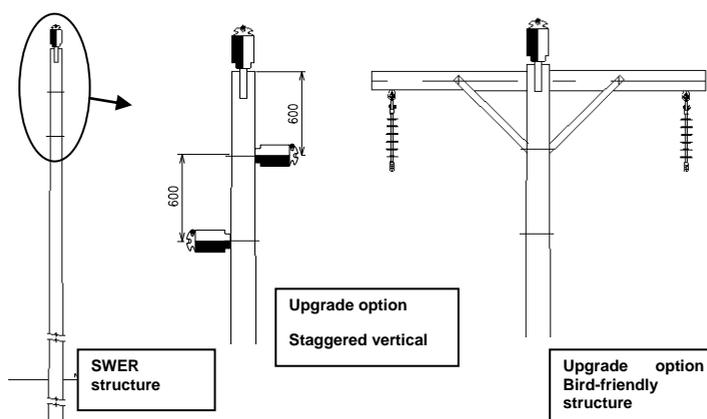
Source: Department of Energy (2009e).

Table 32: National electrification cost in ZAR per grid connection, 2003-2008

	2003/04	2004/05	2005/06	2006/07	2007/08
Western Cape	3 397	2 310	5 311	4 368	12 215
Northern Cape	6 454	5 280	3 871	9 501	4 113
Eastern Cape	5 812	5 805	5 812	15 682	8 515
Free State	2 185	2 389	4 505	4 496	3 996
Kwa-Zulu Natal	5 628	7 962	6 413	8 472	9 412
Mpumalanga	2 256	1 972	5 569	13 742	8 887
Limpopo	3 060	3 735	4 816	4 247	5 939
North West	4 462	4 024	6 496	17 881	9 721
Gauteng	3 689	2 530	7 658	5 044	4 444
Average cost in ZAR	4 430	4 468	5 579	8 995	7 702
28 Feb exc. rate	0.1509	0.1728	0.1629	0.1372	0.1369
Average cost in USD	668	772	909	1 234	1 054

Source: Department of Energy (2009f).

⁴⁸ The School electrification budget is not included as it was supposed to have been completed at the time this budget was being prepared. The household connection subsidy is not specified in the budget forecasts as this is largely a choice to be decided by the municipalities.

Figure 10: Single phase of 3-phase upgrade options for SWER structure

SWER: Single Wire Earth Return

Source: Gendenhuys & McLaren (2007).

Single-wire earth return (SWER) design criteria were reviewed in 1997 to address funding and capacity constraints posing challenges to the electrification of rural villages. The standard was expanded to allow the use of SWER directly coupled to 33 kV three-phase systems with neutral earthing compensator (NEC) earthing. SWER networks were seen as low-cost or cost-effective solutions for the provision of network infrastructure in areas where consumption is low (domestic and few other applications such as limited water pumping). Take-off points are very sparse and lines feeding less than 200 kVA are typically about 100 kilometres long (Gendenhuys & McLaren, 2007).

The South African government supports the principle that basic services should be available and affordable to all. For this reason, to ensure that the poor benefit directly from electrification, they are allocated a 20-amps connection free of charge. Furthermore, there is a 50 kWh free monthly allocation implemented by the municipalities insofar as this is possible for the municipalities. The 50 kWh free basic electricity has been widely debated. While the free allocation is meant to support the poor, the very poor might not yet be connected to the grid. And these very poor might live in poor municipalities that cannot afford the roll-out of the free basic electricity. In addition, high administrative costs are incurred in the application of “means tests” in order to verify eligibility for free basic supply. To avoid these administrative costs, some municipalities have opted to apply free basic allocation to all domestic consumers, with the unintended consequence that wealthy consumers receive the free basic allocation if they happen to reside in one of those municipalities. South Africa has one of the lowest electricity tariffs in the world, with an average selling price (as illustrated below) at around USD 0.027 per kWh. Despite the tariff regime, there is argued and documented energy poverty among both electrified and non-electrified consumers (Department of Energy, 2009g). The poor segment of the population lives below the poverty line and, despite free installation, they may not be able to afford electricity if consumption goes above the free basic electricity allocation.

4.4.2 Non-grid electrification

Specific guidelines have been put in place to cover those segments that cannot be covered by grid extension within the average price and within a three-year plan. In parallel to the general electrification guidelines, special guidelines are in place for non-grid electrification, for

electrification of farm dwelling houses, for electrification or energising unproclaimed areas such as informal settlements.

The farm dwelling incentives (Department of Energy, 2009h) work such that the government pays a locally licensed entity an amount, up to the maximum subsidy payable for the electrification of rural households or the actual costs incurred if it is lower than the applicable subsidy. The subsidy is based on the cost of the lowest supply size stated in the suit of supply options. This amount is determined on an annual basis. As mentioned before, the incentive paid will never be more than the actual cost of connection incurred by the farmer. A certain amount of the incentive will be retained by the licensed entity to cover the administration costs incurred during the electrification project for the farm dwelling houses. This amount may not be more than 10% of the total incentive paid out. The incentive will cover the costs of the low-voltage reticulation costs, the service connection, the meter (including a three-point plug and a light). The incentive will not cover any internal wiring or electrical appliances. The payment of the incentive is subject to a minimum supply size of 20 A being installed and a network built in accordance with relevant industry standards. This incentive will not be given for the electrification of holiday cottages, dairies, sheds, water pumps, churches and schools, etc.

The electrification of unproclaimed/informal areas (Department of Energy, 2009d) was sanctioned by the Minister of Minerals and Energy in February 2005, as a strategy to catch up with backlog and ensure “Universal Access” by 2012 (now 2014). As mentioned above, informal settlements need to be formalised before they can be electrified. The policy stipulates that in order to be eligible for electrification, informal settlements must be in close proximity to existing infrastructure and in a position where electrification is practicable and not encumbered by any potential environmental, geographical, health or safety hazard. Further, the settlement must be stable (*i.e.* there is no further growth or relocation planned for the foreseeable future). The conditions also include that the community supports the proposal and is willing to co-operate with the opening-up of access roads where necessary, keep these access roads clear, supply and organise local labour where required, and help prevent tampering with or reselling of electricity supplies.

4.4.3 Employment creation

The INEP contributes directly to job creation in local areas. Even if many of the jobs are temporary, individuals have received some training and earned some income for up to several years. The DoE has assessed that the INEP will have created an estimated 6 000 jobs in financial year 2008/09 (compared to 3 100 jobs created in 2001/02) (Department of Energy, 2009i). The cumulated number of jobs that have been created so far by the electrification programme has reached 32 995 (Department of Energy, 2009j).

4.5 Country-specific challenges and how they were addressed

South Africa’s rural electrification challenges are those challenges associated with the transformation of society to erase the inequalities from the past.

While articles on rural electrification often plead for special electricity provision for the poor, this argument does not exist in the mainstream debate in South Africa. By declaring that all citizens have an equal right to basic services such as clean water, electricity, access to schools and clinics, the challenge there becomes an issue of delivery, not just allocation of funds. As South Africa has

decided that basic services are to be provided by the government, the concern is on optimising and providing long-term best economic solutions rather than short-term financial solutions.

Pricing

Sustainable implementation and possible adjustment of current tariff policies are open for discussion. Eskom's average selling price was ZAR 0.26 (USD 0.034) in 1979, dropping to ZAR 0.17 (USD 0.022) in 2005 (Molefe, 2008). These low tariffs are one of the causes of the current electricity shortage across South Africa.⁴⁹ Because Eskom has sold electricity at ZAR 0.20 (USD 0.027)/kWh and imported electricity from neighbouring countries at prices around ZAR 0.05 (USD 0.007), it has not been financially feasible for South Africa – as it would not be for any country – to install new power generation. In South Africa alone, the generation margin was only 4% in 2008, leading to endless power cuts and systematic load shedding. It is now generally accepted that tariff changes are needed on top of tariff increases. It is estimated that tariffs will double over a three-year period with the first average 28% increase having already taken effect in 2008. The current debate includes considerations on differential tariff increases to protect the poor, a “home-light” tariff for the low-income sector, a similar tariff for small, micro and medium-sized enterprises (SMMEs), and time-of-use tariffs. This debate is in line with South Africa's rural electrification agenda, as new power generation will be necessary to service more households.

Employment

Employment is a major challenge in South Africa. The average official⁵⁰ unemployment figures are above 20% (see Table 33), excluding the under-employed in the rural and urban areas or those who are not registered in employment agencies.

Table 33: South African unemployment rates

	March 2003	March 2004	March 2005	March 2006	March 2007
Total in %	29.3	26.4	24.2	23.1	23.6

Source: Statistics South Africa (2008b).

As indicated by the results of the 2009 Socio-Economic Survey undertaken by the Department of Energy, the rural electrification programme has generated 32 995 jobs over the last eight years. Payment for electricity is an issue for people who have no or very little income. Many cases of domestic violence in newly electrified households have been amply documented. It is argued that domestic trouble starts over priorities when resources are scarce (Habitat for Humanity, 2009). However, the long-term effect of ensuring universal access to electricity should lead to general opportunities for a broad-based economic development. Providing an area, including a rural area, with modern energy can be seen as a tool to attract businesses that can generate jobs locally, for example in tourism. There are many examples of increased tourism along the entire coastline of South Africa. These jobs and facilities could not have been created without the provision of

⁴⁹ Another major cause was South Africa's indecision on how to proceed with the privatisation of Eskom, which has created much insecurity within Eskom and stalled its plans for capacity expansion.

⁵⁰ The unofficial unemployment rate is closer to the international definition of unemployment since people who have not been actively looking for a job within the last six months are also taken into account, while the official rate disregards them. There are also wide variations between ethnic groups. In the second quarter of 2009, official statistics report 27.9% of Black/African unemployed, 19.5% of Coloured, 11.3 of Indians/Asians and 4.6% of Whites were unemployed.

electricity in the area. The impact on long-term economic development will be interesting to follow and assess.

Capacity

Current generating capacity in Southern Africa is insufficient to meet the demand and the reserve margin is below a safe 10% operating margin. In 2009, South Africa's maximum installed capacity reached 36 208 MW. National plans are in place to expand the power supply, effectively doubling installed generation to some 80 000 MW by 2025 with associated grid expansion and strengthening, but the implementation of these plans is surprisingly slow. South Africa has not built a power plant in over 20 years⁵¹ and, in the meantime, the national expertise to plan, take decisions and manage the complex implementation process has eroded.

Energy efficiency

The productive economy, including the building stock and residential appliances, was established in an environment of low tariffs and abundant supply. The principle "save power" was virtually unheard of until 2005 when South Africa launched its first national strategy for energy efficiency. Despite this new strategy, it was not until 2008 – when severe blackouts hit the country – that South African decision makers were able to win support for changes in the tariff regime and for the creation of energy efficiency targets. The shortage of power is now so severe that nationally mandated energy efficiency measures have been introduced. Large users of energy have been instructed to save 10% power, and municipalities have also asked local customers to reduce electricity consumption. There has been some confusion in the public debate in South Africa where some argue that supplying electricity to the poor is the cause of the present shortage. However, this is unlikely because of the relatively low consumption of poor households. Industry and urban residents are the largest consumers and have been benefiting for a long time. National energy efficiency efforts should be directed primarily to those who consume the most electricity and whose potential for savings are the greatest. In an attempt to maximise and accelerate the reduction of the housing backlog, energy efficiency has largely been overlooked in the design and construction process. Principles are now established to correct these errors and ensure that all houses, including the very small ones, comply with the best-practice energy efficiency standards. South African standard SANS204 does prescribe maximum standards for energy consumption. National departments and donor agencies are ready to support municipalities' efforts to upgrade the housing and building stock so as to prevent future negative impacts on climate change for having neglected the construction industry. The DoE launched the appliance labelling programme for energy efficiency in 2004 in accordance with the EU standards and labelling programme. Unfortunately, there is no financial support to roll out the programme. This is regretful as South Africa and the whole of Africa increasingly receive outdated appliances. The DoE will soon start an industrial energy efficiency programme focusing on system optimisation with the support of the United Nations Industrial and Development Organization (UNIDO), the Swiss State Secretariat for Economic Affairs (SECO) and the UK Department for International Development (DFID). Finally, the DoE is also in the process of signing an energy efficiency project for the building sector to improve efficiency in the construction of buildings and houses, including the use of appliances.

⁵¹ The main reasons are that there were massive overcapacities during the apartheid era and indecision on the government's side regarding the privatisation of Eskom, which stopped Eskom from investing.

Non-grid electrification programme

Off-grid electrification is carried out by private-sector service providers (concessionaires) who have successfully tendered for concessions in designated areas. The non-grid electrification programme which expected to install 300 000 solar home systems (SHS) in 1998 has not managed to reach its objective. To date, only around 50 000 SHS have been installed and programmes are running in only a couple of provinces. Lack of political will and government support has thwarted the process. Some concessionaires have been providing maintenance for the systems, charging on a fee-for-service basis, while others have not provided this service. Non-payment of bills has also been a cause for concern in most concessionaires and lack of expected government capital subsidies has delayed much of the work. Decision making concerning the definition of a non-grid area has also caused delays and costs to the concessionaires. These difficulties have weakened the financial stability of the concessionaires and delayed the installation process.

Renewable energy

Poor policy implementation and lack of clear financial and legal regimes have constrained the development and introduction of new renewable energy sources such as solar, wind, modern bioenergy, etc. Only in 2009 has renewable energy officially been accepted as “real” power and the first national feed-in tariff scheme was established (National Energy Regulator South Africa, 2009). South Africa has one of the best sun regimes in the world. Yet it has one of the lowest penetrations of solar water heaters (SWH). Experience with non-grid electrification through solar heating systems (SHS) has taught a lesson that solar panels are subject to theft and vandalism. Information campaigns and community development programmes help reduce vandalism.

Poor perception of renewable energy

Further, there is a perception that solar energy is not “real” energy; and SHSs are viewed as a temporary solution until the grid can be extended. Some municipalities have begun to install SWH in an effort to prevent load shedding. These efforts are seen to contribute positively to securing sufficient electricity on the grid and to change the perception that renewable energy is not “real” electricity.

Electricity losses

Total electricity losses other than technical vary from between 10% and 15%, which includes system losses and theft (Seshotlho, 2009; Madzhie, 2009). Bypassing of meters is frequent by tapping at the supply points, and is generally well organised by groups of individuals “assisting” members of the local community, usually for a nominal fee. Law enforcement is applied, but illegal reconnections occur with minimum delay, often at the request of the households concerned. The reasons variously cited are inability to pay for supply, or the “entitlement” to a basic right enshrined in the Constitution. Cable theft is a national problem and there is no evidence to support that rural areas or poor areas are more subject to cable theft than other areas (Seshotlho, 2009). Eskom runs regular campaigns to report cable theft, and security patrols are used by both Eskom and municipalities to detect and avert theft. Despite the national power generation shortage, a number of municipalities use 24-hour street lighting as an early warning system of supply interruptions due to cable fault or theft.

Prepaid electricity meters

Prepaid electricity meters form part of the installation for all new connections under the INEP (Smuts, 2007). Initially, their introduction aimed at displacing “conventional” credit meters in order to reduce the administrative costs associated with monthly readings and billings. Further, credit meters were generally mounted on external walls of dwellings (in all residential areas), and suspicion was widespread that supply was accessed by unauthorised users. Hence, prepaid meters,

mounted inside dwellings, offered security while also affording the opportunity for consumers to monitor the consumption of the appliances they use. These meters also reduced the problem of non-payment. When selling prepaid electricity, the challenge of providing a convenient payment point close to every home can easily be underestimated. In most instances, the change from credit meters to prepaid meters was started with a focus on the installation of meters, but it was soon found that the system only started to operate smoothly once the focus included the sales channel as well. From an end-user's perspective, the real delivery process has much more to do with the logistics of moving vouchers (sometimes called "tokens" or "PINs") from a computer where they are generated, to the user's home and moving the cash from the user's pockets to the utility's bank account. However, in the disadvantaged communities targeted by the INEP, few residents have bank accounts. They receive their salaries in cash (often daily or weekly) and when they purchase electricity they do frequent (once a week) small (about ZAR 30) transactions and pay in cash. In most municipalities, this group forms the bulk of the clients. Since either a mechanism (such as an unattended vending machine) or a person is needed to collect the cash during the transaction, this also forms the most challenging part of the community to sell to. However, as long as there is cell phone reception, cell phone vending has few boundaries and can reach informal settlements and newly developed suburbs with very little infrastructure.

Implementation capacity

A major challenge in South Africa is lack of human technical capacity and accurate information from the municipalities. The problem relates to all aspects of electricity markets: number of customers, monitoring of losses, collection of revenue and also information about the number of schools and their electrification status. This is a major reason why school electrification has not yet been completed. Some municipalities have weak institutions and have constrained capacities to provide basic information, thus failing to receive the necessary attention. In very special cases the DoE has allocated funds to build up capacity to manage the electricity supply and collection of revenues.

4.6 Rural electrification progress assessment and conclusion

The South African national electrification programme has shown impressive results. The electrification rate has increased from 30% in 1993 to 73% in 2008 (Department of Energy, 2008a). Ambitious plans are in place to achieve full national access to modern energy, mainly through provision of connection to the national grid by 2014. Policies and funds are also allocated to ensure that areas or individual houses that cannot be connected to the grid can be serviced through different means of modern energy applications such as solar PV.

The cost per connection in 2008 was on average around USD 1 000. The costs vary depending on population density and terrain but the average cost is kept within the planned budgets.

The DoE is responsible for managing the INEP. The programme is carried out through grid connections by Eskom and those municipalities that have been licensed to roll out electrification, while non-grid electrification is provided by concessionaires.

The DoE monitors the implementation through field checks and similar direct follow-ups and initiates corrective measures when results are not as planned. But there has been an implementation deficit at the DoE because of insufficient capacity and poor co-ordination between the non-grid component of INEP and the Renewable Energy Directorate, which is impeding the efficiency of the Department.

There are several reasons why completion of the national electrification programme has had to be postponed from 2012 to 2014.

Household electrification – the main component of the INEP – is under pressure. A major challenge in the household electrification programme is a severe housing backlog. It is estimated that around 1.7 million households (half the estimated total of non-electrified households in May 2009) live in informal settlements. This means that their dwellings are built illegally and are not classified as “houses” because of their unsatisfactory construction. Although households in these informal settlements are entitled to equal access to electricity, it would not be cost-effective to electrify a shack dwelling that may be demolished at any time or destroyed in the next rainstorm. Hence, it is a key government priority that the issues around the 1.7 million households living in informal settlements be addressed first (by their respective municipal councils): either the areas must be formalised, or the inhabitants must be moved to other formalised human settlements before they can be included in the INEP. The DoE’s policy guideline addresses this matter, and a plan and its budget are in place to enable connection before 2014 if the Department of Housing or the municipality arrange for people to live in formalised housing.

A second challenge is the municipalities’ capacity to deliver and oversee delivery of quality electrification. The DoE, which is also facing capacity deficits, seeks to monitor actual performance and to make sure that corrective measures are taken in case of under- or non-performance. Under- or non-performance occurs in those licensed municipalities whose officials are inexperienced in the rolling-out of grid connections. Instead of contracting nationally well-established service providers for the physical implementation of electrification schemes, municipality officials may succumb to pressure by the local communities to support local contractors. The combination of local pressure, weak technical know-how, and stretched municipal capacity in general leads to delays in the implementation or in failure to meet quality criteria. Corrective measures are then required before the DoE releases more funds. In order to accelerate implementation and quality delivery, the DoE has established guidelines for all the stages of the electrification programme and occasionally provides one-off capacity building support to weaker municipalities. In the case of non-grid electrification, non-acceptance of renewable energy systems as a solution for the provision of electricity is slowing down the electrification process.

Electrification of registered clinics has been successfully completed ahead of schedule. Electrification of schools, however, is facing problems largely stemming from lack of information about the number of schools and their electrification status. Some municipalities fail to report the number of schools in their area or fail to provide accurate information on whether the schools are electrified or not. It is clear that this poses a major constraint for the entities in charge of the electrification of the as-yet un-electrified schools. The lack of proper information is indeed one of the many capacity shortfalls at municipality level. Other capacity gaps are improper recording of sales of electricity leading to sub-optimal income streams, and sub-optimal network maintenance. Both the DoE and the National Energy Regulator (NERSA) recognise these challenges and, in very special cases, the DoE has allocated funds to build up capacity to manage electricity supply and the collection of revenues.

An important by-product of the INEP is the adoption of standard methodologies, coupled with a greater awareness of technology options. The standards were established after broad stakeholder consultations, including electricity utility practitioners, equipment suppliers, regulatory bodies and end-user representatives. These standards are now widely used not only in South Africa but also throughout the Southern African region. The INEP provides incentives for a range of new technologies, including planning tools, to meet a variety of site-specific conditions during the roll-out of the programme.

In the case of South Africa's electrification programme the policy of "inventing" technologies specifically for the poor has not been successful. If solar water heating had been used by the richer households and in the cities, then the technology could have been extended to the poorer communities. The rapid flow of information has determined electrification preferences of the people. Cities have been electrified through grid extension. Renewable energy is publicly called "rural energy", and this has led to the negative image attached to all renewable energy applications. The implementation of the DoE programme for renewable energy has been slow and the share of renewable energy in power supply is still insignificant. In 2008, Eskom launched a programme to subsidise solar water heating (SWH), but the subsidy level was too low and required massive administration and control systems so that the programme has had little success. Since 2008 some municipalities have introduced SWH as a way of avoiding load shedding by Eskom. In early 2009 South Africa announced a feed-in tariff for grid-connected renewable energy.

Finally, the South African example confirms what some documentation has revealed: that rural electrification in itself does not lead to economic growth or business development. Rural electrification does not generate local jobs – except those jobs created for the implementation of the electrification schemes. This was confirmed by the Socio-Economic Surveys undertaken by the DoE. Rural economic development needs more than just household electrification. Constraints on the availability of energy and its affordability affect economic development, especially in rural areas. Modern energy services promote economic development by enhancing the productivity of labour and capital. There are important development benefits to be gained from expanding access to modern energy services. In order to achieve rural development objectives, however, there needs to be an integrated approach to the provision of modern energy services and improved information and telecommunication, education, health and transport services. The long-term effect on the population of smoke-free kitchens, and the benefits of being able to read in the evening, watch television, or charge a cell-phone will be interesting to follow. In the case of South Africa, the national electrification plan is an integral part of a broader national development plan. Other initiatives are in place to promote growth and job creation, such as through the development of tourism. Electrifying a new area will open many doors to take advantage of the parallel government initiatives to stimulate economic growth. These initiatives will have more success if they include energy access in their overall objectives.

5 Conclusions and recommendations

The detailed country profiles for Brazil, China, India and South Africa shed light on the main issues that arose as their governments shaped and implemented their rural electrification strategies. These profiles have also served to show successful examples in overcoming major challenges.

The keys to the successful setting-up and implementation of rural electrification policies are drawn from these profiles. Their aim is to encourage policy makers in developing countries who strive to attain the same goals to take time during the electrification process to consider collaborating with one another and within the various IEA energy technology Implementing Agreements or Working Parties.

5.1 Preconditions to successful rural electrification measures

5.1.1 Sound statistical data to map out the populations' geographical distribution and electrification status

A prerequisite to any rural electrification policy is the collection of sound statistical data to map out the electrification needs of a country. The shaping of the policy (including the choice of technologies for electrification and deadlines) will greatly depend on the geographical distribution of the rural population and of the existing grid, the density of this population and its level of electrification. First, lack of information about the location of populations without access to electricity will cause serious delays in the implementation of an electrification policy not to mention the risk of overlooking small-scale infrastructures (isolated schools, health centres, etc.) or remote communities unable to inform about their needs because of their geographical distance. Secondly, the choice of the suitable technology for electrification can only be done efficiently when targets are clearly defined, such as the expected use of electricity and particularly its productive use

5.1.2 Sustained government support and long-term commitment of funds

All rural electrification policies detailed in this Information Paper have implied the full involvement of the four countries' central and local governments. The government support is essential to the development of a successful rural electrification plan. India is a good example. In 2001, the central government launched the "Power for All by 2012" initiative, with all the electricity laws that followed, paving the way for the effective implementation of rural electrification efforts in India, after these efforts had slacked because of the State Electricity Boards' financial problems. The government of India, through laws and reforms which have shaped the country's institutional and legal framework, and through the establishment of dedicated rural electrification institutions, has opted for long-term planning, with centrally determined objectives and target years. Without firm implementation policies and goals that can be enforced through legislation, the electrification process will fall through.

A successful rural electrification programme needs long-term strategic planning and financial resources for its implementation and for long-term maintenance and repairs. Before 2007, lack of sufficient funds was the main reason for the slow implementation of rural electrification in India during the 10th Five-Year Plan. Moreover, if secure and dedicated funds are not available for the longer term once the project is implemented, there will be financial losses and perhaps the de-electrification of previously newly electrified villages. This has occurred in China, where “system integrators” were responsible for the maintenance of their stand-alone systems for only three years after installation. This resulted in some systems being abandoned because of lack of ownership and funds for repairs and maintenance. Such funds need to be included in the electrification plan and made available over a longer period, say 5 to 10 years after installation. Whether these funds are provided through subsidies or through loans, governments should aim at the maximum level of certainty concerning the long-term commitment. Available funds should be “ring-fenced” so that there is no risk of having them misdirected to other government-led activities (GNESD, 2006).

5.1.3 Dedicated institutional structures and independence from political agendas

The creation of transparent and dedicated institutions such as rural electrification agencies (or co-ordinating agencies) and/or a rural electrification fund, largely autonomous and responsible for implementing the country’s rural electrification strategy, is strongly recommended (Barnes & Foley, 2004). Such agencies ensure that funds are allocated directly to rural electrification and not reallocated over time to various national priorities. Their apolitical nature should guarantee the durability of efforts independently of any other political or social goal. They should also develop the necessary standards and guidelines for the implementation of rural electrification programmes. For example, the establishment of the Rural Electrification Board in India has proven to be an effective means of furthering electrification efforts independently of political pressures.

In the same vein, it is also essential that rural electrification efforts remain independent from politicians’ personal agendas. Not uncommon are cases where politicians, eager to gain their constituents’ support for a renewed mandate, interfere with the electrification process. This has occurred in Bangladesh, where one village, and no other, was provided with access to electricity for the satisfaction of politicians’ agendas. The government of Bangladesh has also pledged to construct new lines servicing areas in the constituencies (whose selection was not justified on commercial grounds) of all Members of Parliament (Taniguchi & Kaneko, 2009). The consequences of such administrative corruption are well known, and hinder the development process. When political pressures interfere with the distribution planning, they cause financial difficulties to the utilities or distribution companies if they are forced to operate in a non-commercial manner or are unable to cut the power supply to non-paying customers. For this reason, rural electrification efforts should follow a predetermined, inviolable plan that involves a structured institutional setting. An apolitical monitoring of how rural electrification progresses is recommended. This task can be undertaken by independent institutions created or designated for that purpose.

5.1.4 Establishment of a strong market infrastructure to attract private investors

Participation of the private sector is important when electrifying remote villages, particularly with stand-alone systems. But for the private sector to participate, governments must ensure the

existence of a secure market infrastructure, as all electrification projects need to be viable in order to be sustainable. And as the private sector's viability depends on profits, it will participate in the electrification process only if money flows easily from customer to supplier. As a market in transition, China has tried to encourage private-sector involvement in the electrification process of rural areas through stand-alone systems (although the boundary between privately owned and publicly owned enterprises is not always clear). In cases where revenues are too insecure to attract the private sector, governments could grant subsidies to enterprises that wish to engage in rural electrification programmes. Such policy however has had mixed results (Martinot *et al.*, 2000) and should only be a transitional incentive to encourage private engagement.

5.1.5 Related laws and/or regulations to be carried out alongside the electrification process

First, measures including complementary economic development programmes, alongside the provision of electricity in rural areas, should be introduced to foster business. These measures should ensure that rural areas are governed by good rural markets and have access to credit (Barnes, 2007). Without such complementary measures, business development initiated by the electrification process is likely to slacken. Joint efforts with other ministries or development agencies are therefore recommended to enhance the economic benefits of electrification, as Brazil has done. Through its Territories of Citizenship Programme, a joint ministerial effort to promote economic growth through territorial development, Brazil is in fact striving to improve the quality of life of households in rural or poorer regions.

Secondly, in parallel to the electrification process, the implementation of energy efficiency policies or measures is recommended. Energy efficiency measures such as the use of energy-saving appliances, simple demand-side management measures, or energy conservation in buildings, significantly reduce electricity demand. The Indian Bureau of Energy Efficiency (BEE) for example has taken many energy conservation measures to control electricity consumption in parallel to the country's electrification efforts. But this was not the case in South Africa, where energy efficiency measures were launched only after the 2008 blackouts, during which it appeared that South Africa could not meet its growing demand for electricity. In fact, during South Africa's electrification efforts, energy efficiency measures were largely overlooked. The government, aware of the need for energy efficiency measures, is now working to ensure that all houses comply with best-practice energy efficiency standards. This late compliance, however, has had costs.

5.1.6 Electricity affordability

The issue of electricity affordability is recurrent in the context of rural electrification, as the target groups are usually the rural poor. This said, rural households are usually very willing to pay for access to energy services. When they do not have access to electricity, they often contribute much of their time and revenue to buying or collecting energy sources for their day-to-day needs (Barnes, 2007).

The first hurdle is the connection. Initial payments for the connection are often high for the rural poor. They may have enough to pay for the regular use of electricity but may not be able to afford the connection fees. In such cases, any subsidised electricity is useless for them. When connections are free of charge for the very poor, as in South Africa and India, this first problem is tackled. If

funds are not available, spreading the connection costs over several years will enable larger numbers of customers to be wired, while ensuring the costs are recovered over time by the utility.

The second hurdle is setting the tariff. There is no made-to-measure tariff and there is no good way to set tariffs. Three points however need to be raised. First, there is a widespread belief that, to benefit the rural poor, electricity needs to be sold at a very low price; facts often prove the contrary. In reality, richer communities will benefit more than the poorer ones since they can afford to buy electric appliances, which the very poor cannot. In addition, subsidies should be designed in such a way that only the poorest segments of society benefit from them, and not the better-off communities. Secondly, if the “natural” price is charged, the electricity supplier will be able to effectively and sustainably supply electricity while making a profit that will ensure the sustainability of the electrification process (Barnes & Foley, 2004). Thirdly, rural households are often able to pay for their electricity consumption.

Involving these communities in the tariff-setting process will secure better and more adequate tariff systems.

5.1.7 Effective metering, billing and payment recovery

The effective recovery of customer payments allows electricity companies to supply reliable and sustainable power. Lack of payment for electricity use not only weakens the financial stability of the electricity provider (World Bank, 2000), but also discourages investors to join in on the rural electrification efforts because of uncertain revenues. Adequate metering, billing and payment recovery are fundamental to a sustainable electrification system. When meters do not function correctly, are not properly read or billing is incorrect, then the customer’s actual consumption will not be paid for. Adding to these technical or organisational challenges is petty corruption at the interface with customers, including bribes paid to or requested by meter readers. To tackle these issues, measures such as the creation of franchisees (India), the part-time recruitment of farmers for meter reading (China), or the use of prepaid meters (South Africa and Brazil) as well as stricter management rules (such as random controls) all help to improve the recovery of customer payment, a necessary condition for successful rural electrification efforts.

5.1.8 Full involvement of the rural community throughout the decision-making process

Involving rural communities in the decision-making process has substantially contributed to the effectiveness of these electrification programmes. One tends to believe that rural electrification is the outcome of the sole efforts of governments (central, local or regional) and/or of international development or funding agencies. But the involvement of rural communities in the process, particularly their participation in decision-making committees, has added value to the planning process and given the communities a sense of ownership of the process. Because of their intrinsic characteristics, rural community workers have invaluable knowledge of their region’s consumption patterns, have authority to educate consumers in how to use electricity, can support the utilities in encouraging customers to connect and in training in the use of energy efficiency measures, etc. Both India and Brazil have taken this into account. India, acknowledging that most of the burden of doing without electricity falls on women, has arranged for women to be represented in District Committees, thereby helping in the co-ordination and control of electrification extensions within their district. These committees also check the quality of power and consumer satisfaction, and

promote energy efficiency measures. According to the government of India's statement, the "participation of women in meeting energy needs, especially electricity, is essential for effective, efficient and sustainable implementation of rural electrification programs." Similarly, Brazil through its *Luz para Todos* programme has ensured the involvement of rural communities in Management Committees which work to prioritise activities within the electrification process.

5.2 Stand-alone systems: conditions for successful rural electrification efforts

Different issues need to be addressed to secure the sustainability of the electrification process through stand-alone systems.

5.2.1 *Locally produced and resource-specific technologies for electrification*

If grid extension is not chosen to electrify a targeted region, then the choice of a stand-alone system – whether small, mini or micro-hydro, PV systems, wind energy, hybrid systems, diesel generators, etc. – will depend on many factors. No single technology is to be recommended. Aspects such as the geographical dispersion of the local population, the community's estimated electricity needs and ability to pay, availability of local resources, all factor into the decision-making process. Also, long-term investment from the private sector depends on the climate profile of the territory; the private sector will invest in the safest places as regards climate impacts and will favour climate change-resilient regions. Therefore, decisions will be region-specific, resource-specific, technology-specific (hydro plants in water-rich regions and PV systems in sunny regions, as is the case in China). Rural electrification programmes will also favour locally-manufactured technologies to reduce transportation or import costs.

5.2.2 *Management and maintenance require adequate training, guaranteed assistance structures and customer-supply chains*

Once systems are installed and the electricity service is provided, it is important to make sure that the rural communities – or the actors responsible – are sufficiently skilled to operate and maintain the systems. Lack of any basic skills (including the ability to read the maintenance handbook) may lead to the system being abandoned in case of malfunctioning. It is therefore essential that adequate training be provided to the maintenance actor while the stand-alone system is being installed.

Moreover, accessible guaranteed assistance structures in support of maintenance and repair should be established at the outset of the electrification effort. It is recommended that the target communities – or the responsible maintenance actors – be informed by the installer of how to contact assistance structures. Without such assistance structures and guidelines, there is a risk that the system be abandoned in the longer run.

Finally, just as clear assistance structures are a necessary condition for the sustainability of stand-alone systems in remote areas, it is recommended that maintenance actors should be given clear

guidelines as to where and how to obtain spare parts and maintenance materials. In addition, governments should ensure that suppliers are committed to provide adequate after-sales services.

5.2.3 Sufficient long-term financing to ensure system maintenance

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Financial provision should be made at the outset for the long-term maintenance of the systems. To ensure projects' sustainability, financial support (whether through loans, subsidies or other) should be provided for the installation of stand-alone systems and long-term (5 to 10 year) annual contracts for the maintenance and upgrading of the systems so as to prevent any system failure. In addition, electricity supply can be partially directed towards the development of productive activities to generate funds and so to cover the costs incurred by power supply, operation and maintenance, particularly once the annual maintenance contract has come to an end.

5.2.4 Dealing with the misconception that stand-alone systems provide "second-class" electricity

Electricity supplied through stand-alone systems is not to be regarded as "second class" provision, a problem that is currently observed in South Africa. Appropriate information dissemination and good performance of the stand-alone systems will do away with such issues as lack of ownership, and long-term deterioration or abandonment of the systems will be avoided. Decision makers are to rely on the members of the rural communities sitting in the various supporting committees to redress this misconception within their communities.

5.3 Grid extension: conditions for successful rural electrification efforts

5.3.1 Reducing transmission and distribution losses

Long transmission lines (when extending the grid to rural areas) are at risk of high transmission and distribution (T&D) losses. Line quality and the quality of transformers will also impact the efficiency of T&D. Regular maintenance and upgrading of power lines and transformers will significantly reduce such losses.

5.3.2 Reducing losses from electricity theft

Electricity theft occurs through many different channels. Meters are tampered, or meter readers are corrupt, billing is inadequate or non-existent, revenue is not collected or is not passed on to the utility. Electricity theft can also take the form of illegal hookings (a small metal hook is slung to an overhead power cable and then linked to a house through a cable) which are difficult to prevent or control. All these losses add up and electricity companies are seriously weakened when their service is not paid for. Although theft takes place just as often in urban centres as in rural areas, measures to control and reduce electricity theft are more difficult to apply in rural areas. The introduction of India's 2003 Electricity Act, a law in which theft is considered a criminal offence heavily penalised, dissuades electricity thieves. Other means are the installation of high-voltage distribution systems

(HVDS) which are difficult to hook cables on to. In the case of stand-alone systems in China, PV modules have in some instances been welded to the main structure to create additional hindrances for potential thieves. In South Africa, Eskom, the national power utility, runs regular campaigns for cable theft to be reported, and security patrols are used by both Eskom and municipalities to detect and avert theft.

5.3.3 Use of low-cost technologies

Through the use of low-cost technologies such as single-wire earth return (SWER) as currently used in South Africa for the electrification of rural households, costs of electrification remain controlled. Other standards that allow for cost-effectiveness are the adequate location of transformers, which could depend on current assessed and future electricity demand (GNESD, 2006). Such standards will contribute to moderate electricity prices.

5.4 Three rural electrification boosters

5.4.1 Social fairness can be one of the initial driving motivators in the first stages of electrification

A 2009 case study of Bangladesh showed that the total income gain following electrification reached up to 30% (Khandker *et al.*, 2009). But this was not the result of directing electricity to productive end-uses. In fact electricity provision led to a significant improvement in total study time for children in rural households coupled with an increase in the number of completed school years. The income generated was shown to be sustainable over as long as 8 years. These encouraging results are real incentives to target household electrification as a means of attaining social equity which in the long run will lead to economic growth. Indeed, considering only the productive end-uses of electricity as useful for development is obscuring the actual proven development capacity of health services and education (Cabraal *et al.*, 2005). This also may slow down the electrification efforts. For this reason, social equity can be one of the initial driving motivators of electrification.

5.4.2 Minimising trial and error through benchmarking and exchange with other countries

Though not all emerging economies face the same challenges when working to expand rural electrification, many of the challenges are similar. Whether they live in Brazil, South Africa, China or India, or any developing country, rural populations have the same main characteristics, namely they are often dispersed, difficult to reach, have low electricity consumption needs and low capacity to pay. In addition, countries face the same dual choice between grid extension and stand-alone systems (whatever their size or energy source) and also the same questions regarding the means for financing their electrification efforts (subsidies, loans, grants or other). Often institutional structures or regulatory frameworks need to be introduced or strengthened to encourage investors or the private sector to participate in the electrification scheme. Given the similarity of problems, it is recommended that countries with active rural electrification policies benchmark their activities with those of other countries at similar or more advanced stages. Such information exchange between

countries with similar objectives should take place before and during the implementation of rural electrification policies⁵² to minimise trial and error.

5.4.3 Co-operation within IEA Implementing Agreements for exchange on technologies and support on policy formulation

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Finally, co-operation within the framework of the IEA Implementing Agreements (IA) will provide support to countries seeking to develop their electrification policies. IAs are collaborative programmes whose members⁵³ participate in some or all of the following activities: research projects, programmes for information exchange, policy analysis, technology assessments, feasibility studies, environmental impact studies, market analysis, and more. Benefits of collaborating with other countries within these programmes are “reduced cost and less duplication of work, greater project scale, information sharing and networking, linkage between IEA member countries and non-member countries of the IEA, linkage between research and industry, accelerated development and deployment, harmonised technical standards, strengthened national RD&D capabilities” (IEA, 2007). Members of these collaborative programmes are able to influence the direction of the work of the IAs. It is thus recommended that countries wishing to engage in rural electrification efforts consider participating in these IAs to learn from other countries and share their experience with other country participants.⁵⁴ A list of the relevant IAs can be found in the proceedings of the 2008 workshop on “IEA Sustainable Rural Energisation in Major Emerging Economies” http://www.iea.org/textbase/work/workshopdetail.asp?WS_ID=379.

⁵² Such South-South collaboration is already successfully taking place within the Club-ER (<http://www.club-er.org/>), a club for agencies and national structures in charge of rural electrification comprising 20 member countries, 18 of which are French-speaking African countries.

⁵³ Usually IA members are representatives of countries or independent institutions according to the prevailing contractual agreement between IA members. Any country may join an IA, not just IEA member countries.

⁵⁴ More information on all the IAs and how to join these programmes can be found at <http://www.iea.org/Textbase/techno/index.asp>

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