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Low Cost Electricity and Multi-Sector Development in Rural Tunisia:

Important Lessons from the Tunisian Success Story

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Electricity and Multisector Development in Rural Tunisia*

The Government of Tunisia has strongly supported rural electrification since the early 1970s. Although the program has done many things right to accomplish the country's goal of universal electricity access, one unique feature of the program has been the extensive consultation with other agencies and reliance on funds from rural development programs. The country's leaders understood from the start of the program that electricity by itself will not have the development impact of a program that is integrated into a broader strategy of rural development.

Tunisia's rural electrification program was launched in the mid-1970s, a time when only 6% or 30,000 of the country's rural households had electricity. At that time about one-half of Tunisia's population lived in rural areas. Over the ensuing years, the country has made impressive gains in providing electricity to its rural population. By the end of 2000, 88% of all rural households had electricity service. Today the country has begun a program to serve even the most remote areas with photovoltaic systems. The current goal is to achieve total rural coverage by the year 2010, with 97% household having a grid connection and 3% of households served by photovoltaic systems. The accomplishment is even more remarkable because of the very conservative definition of rural areas, which includes only households outside of incorporated areas. Many populations that in other countries would be defined as "rural" villages and towns are defined as "urban" in Tunisia. Thus, Tunisia's rural population is highly dispersed and isolated, with long distances between small groups of sometimes scattered houses.

Tunisia has been able to artfully balance the sometimes conflicting priorities of having substantial state subsidies, integrate rural electrification with rural development goals, and maintaining the commercial viability of a public electricity company. As Tunisia approaches universal electricity coverage, the question arises as to whether the experience in Tunisia is applicable to rural electrification programs in other African nations. The many factors that contributed to the program's success—strong government policy and financial commitment, gender and social equity, institutional esprit de corps, technical innovation, and uniquely enabling political and economic conditions—are

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lacking in many other African countries. Nonetheless, the Tunisian experience can provide useful lessons—even in some of the most unpromising situations.

History of Rural Electrification in Tunisia

Electricity generation in Tunisia began in 1902, when a French concessionaire that was already providing gas installed the first power plant to service the capital city of Tunis. Various French companies rapidly followed suit, constructing power plants in the cities of Sousse (1905), Sfax (1907), Ferryville (1909), and Bizerte (1911). On the eve of Tunisia's independence from France, in 1956, seven concessionaires controlled the country's electricity generation and distribution. The largest of these companies was the Compagnie Tunisienne d'Electricité et de Transports (CTET), established in 1952, which serviced Grand Tunis and parts of the northwest region. The concessionaires designed their own networks and produced their own electricity or subcontracted producers to maximize profitability of their concession areas and duration of their respective contracts. This resulted in companies sacrificing long-term interests for short-term profitability, making few investments in infrastructure, and alleviating shortages with uncertain solutions.

CTET owned Goulette, Tunisia's oldest and most powerful steam thermal power station (57 MW in 1952). Forces Hydroélectriques de Tunisie (FHET), the country's second largest concessionaire, created in 1952, was responsible for hydroelectric power plants in Ben Metir and Neber in the northwest region. Other companies, which mainly generated diesel, distributed electricity to various cities and urban areas, including Béja, Bizerte, Gabès, Gafsa, Médenine, Sousse, Sfax, Tozeur, and Zarzis. In addition, Tunisia imported electricity from the Algerian Electricity and Gas Company (EGA), which also had interests in FHET. The network consisted of the interconnection with Algeria and the connection between hydroelectric plants in the northwest and Grand Tunis. At this time, rural electrification was extremely limited.

After gaining independence, the Tunisian government initiated a general policy to nationalize key economic activities, including electricity and gas, water, railroads, and banks. In 1958, the government temporarily took control of the concessionaires, replacing CTET and the other companies with management committees. On April 3, 1962, the government nationalized electricity generation and electricity and gas transport and distribution. These activities were entrusted to the Tunisian Electricity and Gas Company (STEG), (as a public utility). At that time, only 26% of Tunisian households had access to electricity.

In the decade that followed, owing to rapid growth in domestic customers and initial extension of the grid into rural areas, electricity consumption increased at a pace of 11.5% annually. STEG concentrated its efforts on rationalizing the system it had inherited from the concessionaires. Electricity generation and transport were developed to meet the demand of new industrial projects, such as El Fouledh steelworks, and the textile industry. In 1965, Goulette 2 was installed, including four groups of 27.5 MW each. In 1972, a power plant was built in the southern city of Ghannouch, which included two groups of 30 MW each and a 15-MW gas turbine. Part of the electricity thus generated was used in Gabès' new industrial units and the rest was transported to other regions through a newly looped system. Electricity generation in Baves was favored through exploitation of flared gas in the southern region (El Borma oil field associated gas) and construction, in 1972, of a gas pipeline connecting the oil field with the Gabès area.

With assistance from the French utility, EdF, and the pro-active education policy of the Tunisian government, STEG developed a cadre of highly qualified technicians and engineers. By the mid-1970s, the utility had established sound business practices and financial sustainability achieved through tariffs related to marginal costs. As indicated, just 6% of rural households and only 37% of all households in the country had access to electricity at that time.

The Tunisian government, now increasingly concerned about the exodus from rural areas caused by lack of public services, turned its attention to expanding rural electrification. In 1973 STEG with the assistance of Hydro-Quebec undertook a technical audit of distribution systems. The audit took into account the government's ambitious goals of providing universal electricity coverage fore the whole country, the potentially quite low levels of rural energy consumption, and high financial requirements.

The main recommendation of the audit was to study a new, lower cost means of electricity distribution that combined three-phase and single-phase lines. Based on the North American model, this system was known in Tunisia as the MALT. Although controversial at the time, the recommendation was confirmed by technical and economic studies conducted for the Master Plan for Distribution in 1974–1975. The studies estimated 18-24% savings using the MALT system. In 1976, the technical decision was made to begin converting to the new system, using three-phase/single-phase lines and 30 kilovolts (kV). On this basis, the Planning Ministry together with STEG set rural electrification goals that were incorporated into the Vth Plan (1977–1981) and subsequent Five-Year Plans (Table 7.1).

The Vth Plan allocated government funds for system expansion and identified villages to be electrified, based on lowest-cost criteria. STEG's main emphasis was on converting the existing distribution system to the MALT system. During this five-year period, 70,000 rural households were connected, and investment costs were fully recovered. During the VIth Plan (1982–1986), 80,000 rural households were connected. Savings from the new distribution system made it possible to connect an additional 10,000 households under the same budget, raising the rate of rural electrification to 28%.

The majority of the financing for rural electrification came directly from the budget of the government. It was not until the VIIth Plan (1987–1991) that Tunisia's government, for the first time, mobilized external funding for the program from the African Development Bank (ADB), the Kuwait Fund, and the French Development Agency (ADF). This initiated a very intensive phase of the rural electrification program. From 1987 to 2000, 429,000 households were connected to the grid, raising the rate of rural electrification from 28% in 1986 to 88% in 2000.

Recognizing that the last remaining households were scattered throughout very remote areas, the National Agency for Renewable Energy (ANER) in 1990 launched a PV program that has now reached about 1% of rural households.

Table 7.1. Evolution of Tunisia's Rural Electrification Program, 1972–2001

	Five-Year Planning Periods					
Factor	IV (1972-76)	V (1977-81)	VI (1982-86)	VII (1987-91)	VIII (1992-96)	IX (1997-01)
Total investment (MTD)		29	52	105	130	134
No. of New Connections	30,000	70,000	80,000	114,000	180,000	135,000
Cumulative Connections		100,000	180,000	294,000	474,000	609,000
% Rural HH With Electric	6	16	28	48	75.7	88.1
% Total HH With Electric	37	56	69	81	90.0	94.9
No. of New HH With PV Systems[b]					3,919[c]	3,838

[a] Implemented through the year 2000.
[b] PV program adds about 1% to rural electrification coverage.
[c] Cumulative through the end of the VIIIth Plan.

National Commitment to Rural Electrification

Tunisia's achievement in rural electrification has been rooted in a strong national commitment to integrated rural development, gender equity, and social equality. The rationale for the national government's long-standing resolve for rural development and modernization was based on the goal of seeks to raise the living standard of its rural citizens, to promote security in outlying regions, and to moderate urban growth.

The three pillars under which rural development was initiated by the country's IVth Five-Year Plan (1972–1976) were basic education, improved health services (including family planning), and rural electrification. These goals were progressively complemented by other development programs, such as roads and telephone networks, better housing, and promotion of rural economic activities.

At the dawn of independence, the population of Tunisia was predominantly rural, with a high demographic growth rate, high infant mortality, and high rate of illiteracy. Improving basic living conditions in rural areas - through the education of children and the improvement of sanitary and health conditions of families - was seen as necessary to laying the foundations for rural development. Mothers were viewed as essential to ensuring education and health, so the decision was taken to give Tunisian women the pivotal role in rural development and to associate women with all rural development efforts.

The Three Pillars of Rural Development—Education, Health and Electricity

The first pillar of Tunisia's rural development strategy formalized in 1972 was education. Since its independence from France in 1956, Tunisia has been at the vanguard of promoting human resources development in the region, with particular emphasis on women's education.

Prior to independence, most Tunisian women were illiterate. The most advantaged women had only an elementary level of education. Even by the 1960s, female university graduates numbered only about 100. Nonetheless, women participated actively in the struggle for national independence. This was perhaps a factor in the keen personal interest of Tunisia's first president, Habib Bourguiba, in promoting women's rights.

Immediately following independence, on August 13, 1956, a Personal Services Code (PSC) was promulgated. Among its other provisions, the PSC abolished polygamy, instituted judicial divorce, gave women the right to vote, and set a minimum age of 17 for girls to marry. The suppression of polygamy, in particular, had an enormous symbolic effect in Tunisia and throughout the world, even though it represented only 4% of marriages in Tunisia.

In the decades following the introduction of the PSC, the Tunisian government invested heavily in education to ensure that women could take advantage of their new legal rights. The emancipation of women, viewed as a struggle against ignorance, emphasized the education of girls. As a result, attitudes toward girls' education changed radically. The principle of co-educational schools was recognized as a fundamental means of progress and was adopted in schools run by the Ministry of Education. Today, more than 90% of both girls and boys are enrolled, and Tunisian women have one of the highest literacy rates in the Arab world. Female students outnumber males in universities; 5,000 women head private companies, and 12% of senior business executives and 35% of doctors are women.

The second pillar in the rural development strategy was health. This program mainly involved provision of basic health and family planning services. Women's right to control fertility and have access to modern means of contraception was central. At the time of independence, female mortality was higher than male mortality. Subsequent improvement of women's access to health services, as well as education, allowed greater participation of women in salaried work, another positive factor for women's rights. Today, Tunisian women have an average life expectancy of 74 years and an average of only 2.2 children.

Rural electrification was the third pillar of Tunisia's rural development program, and the government understood that it was important for it to be coordinated with both education and health. Not only did rural electrification facilitate education and health services as well as the provision of water, and economic activities; it permitted higher penetration of the media, especially television, which introduced rural Tunisian families to various roles for women in urban areas and in other countries.

The national commitment to developing and improving rural living standards involved considerable investments in rural electrification on the part of the government. Such investments were clearly a critical factor in the success of all three aspects of the development program. Government support has proven remarkably steady in weathering political and economic changes

Ways of Financing Rural Electrification—Domestic and International

The commitment to rural electrification was demonstrated through the various budgets utilized for carrying out the program. The primary source of financing the program has been from the Regional Development program, and this was complemented by other domestic funds and international loans.

Since the 1970s, the Regional Development Program (Programme régional de développement) has been the primary source of State funding for rural electrification. PRD allocations for each rural development sector are negotiated between the Ministry of Economic Development (Ministère du Développement Economique) and each regional government (governorate) on an annual basis. In many governorates, rural electrification has had first priority at various times. After the sectoral allocation is negotiated, specific projects are chosen at the governorate level, thereby ensuring local input in project selection. As Table 7.2 shows, of the various rural development sectors that comprised the Regional Development Program investment during the 1997–2000 period, rural electrification represented more than 21% of the total, second only to drinking water.

In 1984, the PRD was supplemented by the Integrated Rural Development Program (Programme de développement rural intégré [PDRI]), which the State also funded. Although small compared to the PDR, the PDRI takes a more integrated approach to rural development. It offers beneficiaries integrated assistance across many areas, such as vegetable and production, irrigation, and electrification.

In addition to the Rural Development Program in which funding was allocated according to a strict planning criteria, a program was created to assist projects that failed to meet the usual criteria. The President of the Republic created two extra-budgetary funds. The first was a special Presidential Fund, which finances projects that the president selects at regional ministry-level meetings and during visits throughout the country. The second was a National Solidarity Fund (Fonds de Solidarité Nationale), which the president created in 1992 to improve Tunisian living conditions, particularly in underprivileged areas (*zones d'ombre*). Voluntary contributions to the FSN are solicited from nongovernmental organizations (NGOs), public and private businesses, and Tunisian citizens. As a result of this financing, the rate of rural electrification has been increased by an estimated 10%. These personal initiatives of the president, supported by contributions from a broad spectrum of society, exemplify the country's strong political commitment to rural development, and to rural electrification in particular.

Table 7.2. PRD Rural Development Investments, by Sector, 1997–2000

Sectoral Activity	Amount (MTD)	% of Total Investment
Drinking water	373.7	45.9
Rural electrification	172.7	21.2
Roads, bridges, and streets	150.0	18.4
Education and teaching	47.0	5.8
Post offices and telephones	32.4	4.0
Flood-protection works	19.8	2.4
Health	7.8	1.0
Youth and children	7.5	0.9
Professional training	3.7	0.5
Total investment	814.8	100

Source: Rapport annuel sur le développement, 2000.

Later in the program, the government also borrowed money to financing rural electrification. Since 1977, the State has incurred more than 200 MTD in external debt—not always at concessional rates—with which to finance rural electrification. The most significant source has been the African Development Bank (ADB), which has provided five lines of credit for rural electrification or about 80 percent of external financing. Other funding sources have included the World Bank (7.8%); Agence Française de Développement (7.5%); and the Kuwait Fund (2.6%). Together with ADB support, these loans have helped to finance the connection of 376,000 rural residents, 61.7% of the 609,000 rural households connected during the times of these investments.

Finally, national commitment to total rural electrification has been demonstrated by the development and funding of an ambitious, high-quality PV program, established in the mid-1980s to reach the most isolated households that otherwise would not meet the selection criteria. This program is financed primarily, not by beneficiary and regional-government contributions, but through suppliers, World Bank credits, and NGOs.

Effective Institutional Structure for Project Planning and Selection

Tunisia's rural electrification program benefits from an institutional structure that has proven highly effective in achieving a rapid growth and spread of rural electrification. An iterative five-year planning and implementation process balances economic and social criteria and imposes financial discipline on rural development projects, including rural electrification. The system is characterized by centralized planning, with major regional and subregional inputs and initiatives. This is done within the framework of a comprehensive rural development program.

Tunisia's rural electrification program is influenced by various social, economic, and technical factors. Multiple institutions are involved in developing and implementing rural electrification programs. At the national policy and planning level, these primarily include the MDE and the MI, with input from STEG and the ANER. At the regional and local levels, regional governorates and their subdivisions, called delegations, provide input into rural development planning, while the STEG and ANER are responsible for implementation.

At first glance, having so many agencies involved in rural electrification appears unwieldy. However, these disparate entities are unified through well-defined roles an official coordinating body, and a planning and implementation process that guarantees continuous interaction between agencies. Clear criteria govern the selection of rural electrification projects. All cooperating agencies are aware of the criteria governing the process and can concentrate on efficient implementation. Such close cooperation continues throughout implementation

Well-defined Roles and Mandates for Agencies

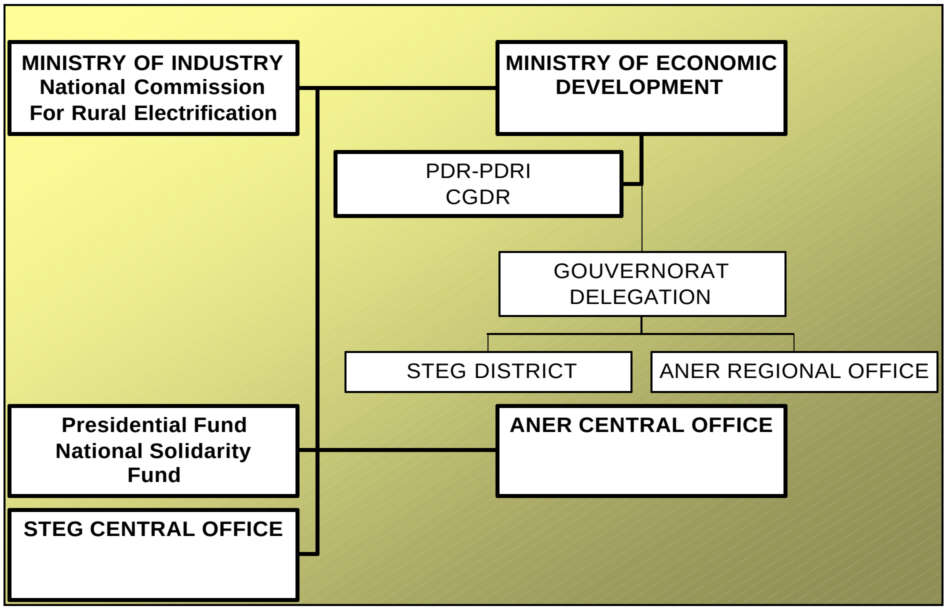
Each agency has a clearly defined role and mandate in rural electrification. The MDE, in collaboration with its specialized agencies, including the General Regional Development Commissariat (Commissariat Général de Développement Régional [CGDR]), defines overall rural development policy and this provides the framework for rural electrification. The MDE is charged with disbursing a share of national revenue to subsidize rural electrification projects in a cost-effective and equitable way. It mobilizes finances, and divides the national budget for rural development between the regional governments and implementing agencies. Both the PDR and the PDRI are housed within the MDE.

The MI develops Tunisia's energy policy. It is responsible for supervising the various branches of the energy sector: hydrocarbon exploration and production; refining and distribution of petroleum products; and production, transport, and distribution of gas and electricity. As part of its mandate, the MI houses the National Rural Electrification Commission (Commission Nationale d'Electrification Rurale [CNER]) and has supervisory authority over STEG. It also provides input into the five-year planning process.

The governorates, in their role as regional executive agencies of the Ministry of the Interior, are charged, together with their delegations, with selecting rural development projects, including rural electrification projects, and allocating funds disbursed from the national budget, in addition to their own resources. The governorates are also responsible for overseeing the timely and efficient completion of projects. Thus, the governorates and their delegations provide, at an official level, primary regional and local input into project selection and design. In identifying rural electrification projects in their jurisdictions, the delegations also consult with *oumdas* (leading citizens who act as spokespersons for local interests).

The two implementing agencies—STEG and ANER—also have clearly defined roles. As the national electric utility, STEG is responsible for electricity generation, transmission, and distribution, as well as transport and distribution of natural gas. Although STEG falls within the MI's jurisdiction, it enjoys considerable autonomy in practice, especially in technical matters. However, decisions of a broader social nature, such as changes in tariffs, are made in consultation with the MI.

Figure 7.1 Diagram of Responsibilities for Rural Electrification



STEG is responsible for implementing the major part of the rural electrification program—that based on grid extension. It maintains a regional organization that parallels the governorates. Thus, STEG districts largely coincide with governorates, facilitating regular consultations between the two bodies. STEG is the direct counterpart of the governorates in rural electrification projects. As a statutory government corporation established by Decree Law No. 62-8 of 1962 on nationalization, STEG is responsible not only for grid-based rural electrification projects, but for the entire electricity sector, including generation, transmission, distribution, and export, as well as distribution of gas under the MI's supervision.

ANER, which is under the administrative supervision of the Ministry of Environment, promotes energy conservation and development of renewable energy. ANER undertakes PV-based rural electrification projects that aim to connect households remote from the grid. Although much of ANER's activitiy is centered at its Tunis headquarters, it has offices in the three regions (El Kef, Sidi Bouzid, and Gabes) where it has the most projects.

Agency Coordination

Recognizing that many agencies are involved in rural electrification, considerable efforts are made to ensure their coordination. At policy and implementation levels, coordination is achieved both institutionally and systemically.

The CNER, a coordinating body chaired by the MI's Director of Electricity and Gas, includes representatives of STEG, ANER, MDE, Ministry of Environment, Ministry of the Interior, and FSN. Through regular meetings, CNER keeps members informed of rural electrification activities that are carried out throughout the country. It provides a forum in which policymaking, planning, and implementing agencies can exchange views and identify problems.

Such a coordinating body, though useful, is rarely adequate to cope with the entire range of issues that arise during the planning and implementation of a major program. Therefore, in Tunisia, CNER's work is supplemented by continuous interaction—both horizontal and vertical—between agencies. For example, two-way communication between the MDE, MI, STEG, ANER, and CNER is continuous when the five-year plans are being drawn up to arrive at rural electrification targets consistent with available financial and technical resources. Similarly, at the regional level, the governorates interact continuously with STEG districts and ANER offices during program execution.

The contents of the five-year plans' rural electrification programs are also developed iteratively through two-way communication between central and regional authorities. In fact, the first estimate of rural electrification projects within the overall rural development budget, established by the MDE, originates at the subregional (delegation) level. Far from being entirely top-down, the process incorporates a substantial amount of bottom-up content, at least at the official level.

Planning and Implementation

The dynamics of this coordination are further illustrated in the planning process, from initial design of the national rural development budget in the five-year plan to the selection of specific rural electrification projects.

The criteria governing these choices are an important aspect of a successful rural electrification program. During most program years, more villages or households wish to be receive new electricity service than there are funds available to do so. It is therefore important to ensure that rural electrification planning is open and objective and uses clearly-defined criteria to rank villages and households for connection. Clear criteria respond to concerns about social justice or fairness, reduce local political pressure to "jump the queue," and allow for a more rational and economic, long-term electrification program. They also greatly facilitate the planning and implementation of rural electrification projects, as they eliminate potential contention between cooperating agencies.

Tunisia has established a project-selection method that is orderly, transparent, and meticulous. Rural electrification plans and targets are made publicly available so that progress can be monitored and assessed. In the STEG program, which accounts for more than 90% of connections, selecting sites for electrification is a two-step process. For the first step, within the framework of the current five-year plan, the MDE identifies the delegations or zones to include in the rural development program. Selection is based on such criteria as income level unemployment, environmental quality, gender status, expected rate of return from projects, and the costs involved in job creation and improved living conditions.

In the second step, potential rural electrification projects are identified within the delegations and zones selected in the first step. The governorate asks the delegations to list all non-electrified agglomerations, defined as a minimum of 10 households or adjacent households no further than 200 m apart, built with walls and roofs of permanent materials. Potential sites for electrifying agricultural pumping and water drilling in the delegations are also identified. This list is drawn up in collaboration with the local *oumdas*.

Next, STEG district offices in each governorate review this list in detail. They make site visits to verify the information provided by the governorates and collect additional data, including lengths of needed medium voltage (MV) and low-voltage (LV) lines that are available, number of transformers, and number of housing units suitable for electrification. This information is then mapped onto the existing grid.

In this way, a database of economic and technical information is constructed for each STEG district. This information is processed in STEG's computer-driven economic feasibility model in order to evaluate the investments per project or grappe (several projects served by the same medium-tension [MT] line). STEG headquarters then estimates costs, based on STEG unit costs, of electrifying the various households, agglomerations, and pumping and drilling sites. On the basis of this estimate, a table is prepared showing the number of households that can be electrified at various cost levels, and estimating the total costs of providing electricity to the number of households at each cost level.

This process permits STEG to provide the MDE scenarios for electrification. Each scenario gives, for each governorate, the number of beneficiaries, cost of projects, and rates of electrification. Once the rural development objectives of the five-year plan are fixed, these scenarios are used to establish project costs. For example, in the IXth Plan (1997–2001), the MDE fixed the ceiling at 2,200 TD (of which beneficiaries pay 200, STEG pays 200, and the State pays 1,800). Thus, all projects that cost less than this ceiling are selected for inclusion in the provisional five-year plan for rural electrification, based on grid extension; however, projects that cost more than 2,200 TD may possibly be included in supplementary programs, such as the PP or FSN.

At the regional level, the governorate, in collaboration with the STEG district office, adopts these projects and the funds allocated by the MDE for rural electrification. The CNER then checks for inconsistencies between the adopted governorate rural-electrification projects and those in other programs, such as the PDR, PDRI, PP, and FSN. The governorate program is finally confirmed at the national level in meetings between the MDE, governorate, STEG, and ANER. The five-year plan is the consolidation of the various regional plans.

Regarding the much smaller ANER program, the number of households that could benefit from PV systems is based on census data, results of STEG inquires, and a 1995 study estimating the role of renewable energy that concluded 70,000 households would not be served by the grid. On this basis, ANER planned in the VIIIth and IXth Five-Year Plans to install 10,000 systems (of which 7,700 have been installed).

ANER's selection process is largely determined by the advance of the grid-connected system. In the past, because of the time lag between ANER project definition and installation (as long as two-to-three years), PV projects were sometimes overtaken by arrival of the grid. In other cases, the grid arrived shortly after the PV project had been implemented, thereby duplicating efforts and wasting resources. For example, in 20% of cases, the grid arrived to connect households within three months to a year after they had installed PV equipment.

To avoid such duplication, coordination between ANER, STEG, and the governorates is being tightened. ANER now asks each governorate to provide a list of potential beneficiaries of PV systems. The list is based on rural development needs, present and projected distance from the grid, and householder interest. Increasingly, efforts are being made to ensure that projects are situated well beyond the anticipated extension of the grid. The list is therefore checked with STEG before program implementation.

Achievements and Challenges

Rural electrification experience throughout the world suggests that there is no single institutional structure or process for success. Regardless of the structure adopted, however, certain characteristics are essential. These include clarity of purpose, well-defined roles for all agencies involved, and established procedures that ensure equitable agency coordination. As noted above, the Tunisian system scores well on all counts.

Nonetheless, Tunisia's rural electrification program has its shortcomings. Coordination has sometimes broken down, as the above example of duplicating PV systems and grid extension projects illustrates, resulting in wasted resources. Moreover, while the project-selection process appears admirably clear and transparent, it may be criticized, in practice, for verging on the mechanical, especially in cases where local costs diverge from the national averages used to estimate total costs of rural electrification. Finally, although the selection process is initiated at the community level, in consultation with the local *oumda*, this input is considered official rather than at the citizenry level, and could therefore be incomplete.

On balance, however, the successful record of Tunisia's rural electrification program reflects its efficient, well-coordinated processes, as well as its perceived fairness. These factors, in turn, have reinforced a national commitment to improving living conditions for rural residents by making rural electrification an integral part of the country's broader rural development program.

Implementation Through STEG--An Effective Utility

The STEG's long record as an effective, efficient utility has earned it an international reputation as one of the best developing-country power utilities in the world (Hicks et a. 1993; ESMAP 1991). Insulated from unwarranted political influences through its mandate, STEG has been a key partner in Tunisia's rural development. It is viewed as a model enterprise in the Tunisian government and economy, having attracted the best and brightest Tunisian engineers and economists to implement the nation's rural development mission during the 1970s. Two decades later, the high level of confidence vested in STEG's technical assessments still plays an important role in the successful adoption of cutting-edge technology.

Several operational factors have contributed to STEG's success. They include the encouragement of private sector participation in the construction phase of rural electrification projects and the promotion of a local supply industry for equipment and material. STEG also developed a sophisticated computerized inventory management system and rigorous commercial practices, including control of non-technical losses and effective billing and connection payment practices. Finally, findings on customer satisfaction and quality of service are analyzed.

Mandate and Management Structure

STEG is a statutory government corporation, of a commercial and industrial nature. Established by Decree Law No. 62-8 of April 3, 1962, STEG, under the MI's supervision, is responsible for the generation, transmission, distribution, import, and export of electricity and natural gas. The utility's three departments and 15 directorates report to the chairman and managing director and are responsible for operating the electricity and gas systems and managing the utility.

The Directorate for Electricity and Gas Distribution has primary responsibility for rural electrification, through its Department of Program and Budget, Logistical Directorate, five Regional Directorates, and 34 District branch offices. This Directorate is supported directly, however, by the General Management, which approves plans and budgets, and by central administrative STEG units, including the Directorate for Finance and Accounts, Directorate for Studies and Planning (which sets tariffs), and the Directorate for Human Resources and Legal Affairs (which trains external contractors).

STEG's 14-member Board of Directors includes a Chairman and Managing Director, Assistant Managing Director, nine members representing the State (including a representative of the Ministry of Environment), two members representing employers, and one financial controller. STEG also has a cooperative agreement with the Association of Consumer Protection to provide consumer input through regular meetings with STEG headquarters, as well as with field offices and the newly implemented call centers.

STEG's organizational structure reveals two key reasons for its success in rural electrification. First, the utility has enjoyed the backing of highly professional, experienced administrative units within a large corporation with well-established operating and customer-management procedures. Second, it has benefited from a highly decentralized implementation structure since 1977, when the decision was made to establish district offices in each governorate. Today, in fact, many governorates have more than one STEG district office, which facilitates coordination with rural development planning through the local selection of STEG projects in close cooperation with the regional administration.

Early Computerization and Development of Software Applications

STEG was the first major Tunisian corporation to computerize operations. This occurred in the early 1970s, the same time that the country's rural electrification drive was launched. By the late 1970s, nearly all departments had been computerized, which allowed a sophisticated level of data collection, analysis, and management that contributed greatly to STEG's ability to monitor and improve its performance in all areas, including rural electrification.

During the mid-1970s, various software applications fundamental to the everyday operations of STEG were designed and adopted. These included activities such as personnel and salary management, billing and collection, and inventory management. During this initial period, STEG emphasized software development as an operational and business management tool. Engineers and software technicians were recruited to design and put in place these software applications. Software applications were also developed to facilitate the design of rural electrification systems. These included the Tanouir software for sizing MV lines and the software for daily account records of LV customers.

Transparent Norms and Guidelines

STEG's operational norms and guidelines, updated regularly, are used by both STEG technicians and outside contractors to ensure a standardized approach and adherence to contracts. These guidelines illustrate the attention to details that is paid by the company.

The Section on Specific Administrative Clauses (Cahier des Clauses Administratives Particulières) covers all administrative details, such as costs that can be included in bids, those for which STEG is responsible, escalating factors for unit costs, terms of payment to contractors, general billing conditions, applicable taxes, penalties, insurance requirements, construction supervision, and project acceptance by STEG.

The Section on Specific Technical Clauses includes all general specifications for project construction, such as tolerances when laying out lines, transport and handling procedures for various components, specifications for preparing concrete, installation of line hardware and proper stringing of conductors, and preparation of grounds.

The Technical Guide to STEG Electricity Distribution includes all specifications for the design and construction of rural electrification projects and is supplemented by a series of documents detailing Tunisian standards.

The Global State (Mercuriale) is prepared by STEG every 12-18 months on the basis of the historical rural electrification costs. These costs are prepared for each assembly that is used in a rural electrification project and include supply costs plus storage fees, overhead, in-country transport from central storage to job site, and installation costs. The Mercuriale facilitates the preparation of invoices for construction, equipment, and services rendered by STEG for its customers, as well as the calculation of project costs, regardless of source of project financing.

The Tariff Contract contains unit costs for each task undertaken during project construction as a basis for payment to small enterprises. This document is revised every three years for each zone on the basis of unit costs bid by the large enterprise that is the lowest bidder for large projects in that specific zone (minus the transport costs from central storage to the district, which is STEG's responsibility for small jobs). Taken together, these guidelines have provided an implementation framework for rural electrification that has reduced costs and raised efficiency considerably through standardization.

Successful Project Implementation and Construction

STEG's successful implementation and construction of rural electrification projects are based on four major factors. The first is the encouragement of private-sector participation during the construction phase. Secondly, local industry is developed to supply equipment and material. Also, a sophisticated, computerized inventory management system is used. Finally, rigorous commercial practices are in place, including control of non-technical losses and effective billing and connection payment procedures.

Private-sector Participation in Construction

Most rural electrification projects are constructed by outside contractors, not STEG. More often, STEG's role involves project planning and design, selecting and training contractors, procuring and managing grid supplies, developing detailed standards and guidelines for construction, and monitoring and evaluating completed projects. This approach has succeeded in maintaining low costs and ensuring quality construction, as well as supporting the development of local expertise and enterprises.

Both large national enterprises and small local firms participate in the construction of rural electrification projects. Those projects whose labor costs exceed 30,000 TD are bid upon. A verification committee, composed of independent evaluators, uses a technically and financially rigorous process through which to evaluate the bids. For projects whose labor costs are less than 30,000 TD, STEG's district office selects small local firms, based on their availability and technical capacity. In 1992, 36% of Tunisia's rural electrification construction was undertaken by large enterprises, 56% by small firms, and the remaining 8% by STEG itself.

When the drive toward rural electrification first began, the country's few local enterprises lacked the skills needed to construct medium-voltage/low-voltage substations and lines. STEG encouraged these firms to increase their competence by providing trainers from the Sectoral Center for Professional Training (part of the Tunisian Agency for Professional Training). In 1999–2000 for example, this Center trained 30 foremen and 63 linemen, who represented firms from throughout Tunisia. This training program has helped to establish a qualified cadre of rural electrification contractors in all regions.

As projects progress, STEG technicians regularly check their adherence to the utility's technical distribution guidelines. STEG prepares regular project status reports, which are submitted to the regional governments, the MI (which supervises STEG), and financing organizations. Once projects are completed, a STEG team carries out an inspection to ensure that they conform to the terms of the contract and relevant construction norms. Since STEG assumes all financial responsibility for subsequent use of the system, these inspections are quite rigorous. The contractor must remedy any inadequacies before payment is made.

Participation of Local Supply Industry

Tunisia's rural electrification program has encouraged the development of national industries to supply its needs. In externally-funded projects, local suppliers compete directly with international firms (with a 15% preference given over the lowest international bid), which has pushed local suppliers to improve their product quality and adjust prices to the international market. The bidding process for electricity grid supplies is meticulous. Pre-defined rules are followed for deadlines, method of evaluating technical bids independent of price bids, and method of submitting bids for specialized commissions' approval. These rules guarantee maximum transparency and give suppliers the confidence to make their best offers. Currently, the average share of Tunisian suppliers of grid materials is about 64%.

Now that Tunisia's electrification market is nearly saturated, suppliers are turning toward export markets. According to the World Bank (2000a), exports of electrical machinery are booming, having grown from 1.2% in 1980 to 7.5% in 1997, and now poised to grow even more. Thus, STEG's strategy of using local suppliers appears to have not only reduced its own costs, but to have also encouraged growth of a national export industry.

Rigorous Commercial Practices

The electricity company also follows rigorous commercial practices in its minimizing of non-technical losses, billing practices, payment collection, and debt reduction. In Tunisia, non-technical losses—the financial losses a utility incurs when the power it supplies is consumed but not paid for—are comparable to those of developed-country utilities. In the STEG distribution system, non-technical losses have been minimized, largely as a result of a customer management improvement program introduced in the 1980s, which reduced losses significantly. For the entire distribution network, in the early 1990s it was estimated that there are only 10.3% technical losses and only 3.1% non-technical losses for a total of 13.4% system-wide losses (ESMAP 1991).

In rural areas, fraud and meter tampering are minimal. One major reason is that rural customers have more respect the electricity utility than urban consumers. Also, meters in rural areas have been installed more recently than those in urban areas. Therefore they are less often damaged so billing problems caused by damaged meters are rare.

STEG's policy on illegal connections may also be a deterrent. This policy includes frequent, regular monitoring and meter inspection campaigns. Meter readers are rotated regularly among districts. Abnormally low consumption is investigated after generating computerized lists. In addition, bonuses are given for identifying cases of fraud and strict legal action is taken in such cases. On the technical side, insulated cables are used for networks and supply lines to prevent illegal tapping of power lines by customers.

Customers are automatically billed from two computer centers: one in Tunis and another in Sfax. In the early 1970s, STEG set up an integrated billing software program, whose effectiveness has been proven through thorough testing. The first customer who requests a connection activates the system. Each customer file is followed closely through connection, cash payment, hook-up, and finally metering and billing of consumption. This system allows for daily monitoring of consumption and regular monitoring of installed meters to avoid unaccounted for consumption.

The software used can monitor meter readings and signal any deviation in the bi-monthly reading regarding a customer's historic consumption pattern. This allows the detection of index errors and signals any potential cases of fraud as soon as any unexplained changes in consumption levels occur.

Although low voltage customers are billed bi-monthly, meters are read only every six months in rural areas (compared to every four months in urban areas, and every other month for government offices and water pumping). Thus, for rural customers, between each meter reading, two bills are estimated on the basis of the average bi-monthly consumption over the last three rolling years. When the meter is read, the actual consumption is calculated, and the amount paid in intermediate bills is deducted. Large customers are metered and billed on a monthly basis. Billing is spread out over time in order to better divide the handling of customer files and cash flow during the month.

STEG agents deliver statements to customers' business addresses or residences within three-to-five days; however, this method is expensive. Postal service is also considered unreliable, expensive, and faces delivery problems similar to those of STEG. Both the postal service and STEG leave bills for more isolated rural customers at the local general store, which serves as an informal post office. This can result in payment delays and cutting off of service for rural customers.

In most rural areas, customers give top priority to paying their electricity bills. Most unpaid bills originate in the public sector, but, as Table 7.3 shows, payment by LV customers has improved in recent years. Unpaid bills for LV customers (both rural and urban) represented less than 5% of STEG's total unpaid bills in 1997–1998.

Table 7.3. Comparison of STEG's Unpaid Bills, 1990 and 1997–1998

Unpaid bills	1990		1998	
	MTD	%	MTD	%
Total public sector	21.3	81	48.1	79.6
Total private sector	5.0	19	12.3	20.4
LV customers (rural and urban)	3.2	12	2.9	4.8
Total	26.3	100	60.4	100

Payment facilities for connection costs are extremely generous, as STEG has learned from experience that rural households can maintain only low monthly payments. When the rural electrification program was first launched, customers had to pay their connection fees over a 10-month period. When even this proved unaffordable for many rural customers, the amount was progressively spread out over 40 months in 20 bi-monthly payments, and later extended to 72 months in 36 bi-monthly payments, where it remains today. This policy of spreading out payments has greatly reduced the monthly bills of connecting households; as a result, there are few non-payments.

Analysis of Customer Service: Problems and Solutions

STEG has sought technical answers, such as innovative billing practices and the MALT system, to resolve customer-service problems. However, little monitoring of customer satisfaction with quality of service has occurred. It is assumed that the economic cost of an undistributed kilowatt hour in a rural area—characterized by low electricity demand—is much less than one in an urban area, that daytime power outages will often go unnoticed by customers, and economic losses are insignificant.

According to the informal field work carried out for this chapter, power outages, though infrequent, did occur in the villages studied. Some were programmed (as part of works in progress), while others were unanticipated (due to natural causes, such as violent weather). Health clinics have complained of not having been informed of prolonged outages, which have resulted in spoiled refrigerated vaccines. To protect against such damages, some clinics have had to reduce vaccine inventories or have had to maintain emergency coolers. Communications problems between STEG and its consumers were also discovered. For example, rural customers have had difficulty in contacting STEG because of out-of-order or inaccessible telephone booths or because they believed the utility would be automatically informed about the problem.

Voltages fluctuations have damaged domestic appliances and television sets. When regional development authorities and agricultural and agro-processing customers were interviewed for this study, it was found that voltage fluctuations had damaged electric motors used for water pumping.[1, 2] In the future, such fluctuations could increase as the network expands to include houses located remotely from MT/LT substations.

Agro-processing customers in the areas studied were also concerned about lack of access to three-phase power (single-phase power prevails in rural areas). Private silos, usually located near grain fields, require three-phase power because they are fed by electrogenes groups. Refrigerated collection centers require a power of 15-22 kW and three-phase power. Rural development authorities also mentioned projects that companies are prepared to invest in and that are located in areas where water is available; however, power is limited to the single-phase grid.

Over the past two years, STEG has launched a high-priority effort (*ecoute client*) to improve how customer problems are resolved. Customer service representatives are employed in branch offices to handle customer billing problems and complaints. Moreover, pilot call centers have been set up in certain districts to handle customer inquiries. Additional monitoring of customer needs and service levels is needed in rural areas, which perhaps could lead to educational campaigns for customers and to alternative approaches by the utility.

Financial Sustainability From Grants, Loans and Revenues

Unlike many developing countries, Tunisia has implemented its rural electrification program without undue stress on government or implementing-agency finances. Four major sources of financing and subsidies have contributed to this achievement. First, during much of the period of rapid rural electrification, Tunisia's economy grew at a fast pace (4-5%), thereby generating adequate budgetary support. Second, decline of investment in electricity generation during the 1980s released funds for rural electrification. Third, rural consumption represented only 4% of total consumption, which minimized the effects of subsidies on operating costs. Fourth, Tunisia had access to loans and grants from a wide range of international donors and agencies.

Rural electrification typically has involved both high capital costs and some type of subsidies. As the grid is extended into new areas, there typically is some type of capital subsidy for system expansion. Once in place, for the most remote areas some type of cross-subsidy also is needed to offset the prohibitive costs of providing electricity service to remote communities. These aspects of the program are explained in detail in this section.

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[1] One disadvantage of electric water pumping for agricultural use is that it rapidly exhausts the water table. For this reason, it must be carefully monitored. The water authority sets maximum outputs, which farmers cannot vary according to their needs; therefore, a reservoir must be constructed.

[2] Some farmers and water associations also complained about bi-monthly billing (they would prefer monthly bills), inconvenience of peak-load management periods, power-factor penalties, and taxes on electricity bills.

Financing Grid Expansion

Grid expansion was achieved through effectively mobilizing STEG, beneficiaries, and state resources. Although each contributed, the state bore the largest share, either through domestic budgetary resources or borrowing from various international organizations. Since 1977, a formula has been used to define the rural electrification contributions of each of the three funding sources This type of subsidy is very similar to those being advocated for privates sector companies involved in rural electriciation, but in this case it is for a public company (Brook and Smith, 2001) In the case of Tunisia, these incentives have been provided to the public electricity company, and have worked quite well.

Beneficiaries are also required to participate in the cost of connections. This participation is fixed at a level of 200 TD, calculated so that electricity costs less than expenditures on alternative energy sources (candles, kerosene, or batteries). As initial connection charges are often a barrier to low-income rural families, STEG spreads them out as 36 bi-monthly payments. In some regions, beneficiaries have agreed to contribute more than the required 200 TD to expedite household connection (for example, Bizerta's level is 273 TD, Nabeul's is 400-600, and Sfax's is 400).

With regard to STEG's contribution to grid expansion, a cost ceiling per average connection has been established. This simple, workable formula sets a limit on STEG financial participation and provides incentives to undertake economically justified investments. From the Vth Plan (1977–1981) through the VIth (1982–1986), STEG contributed up to 100 TD per household connection and 250 TD for agricultural pumping, thereby providing an additional incentive for the more immediately economically productive activity. However, since 1989, STEG's participation in household connections increased to 200 TD, reflecting higher costs and a special national effort to improve the quality of rural life.

For each project, an average cost of electrification is calculated in terms of an upper and lower limit. The lower limit equals the maximum STEG connection contribution and the beneficiary's contribution (each gives 200 TD per domestic connection). Thus, projects costing less than 400 TD are considered feasible, and are financed by STEG. However, for those projects costing more than 400 TD, the state provides a subsidy to the company equal to the additional costs incurred. For such projects costing more than 400 TD, a maximum or ceiling is defined every five years in the Economic and Social Development Plan. For the IXth Plan, this ceiling was set at 2,200 TD. Those projects that lie between the lower (400 TD) and upper (2,200 TD) limits are co-financed by the State under such programs as the PRD and the PDRI. Projects costing more than the maximum (2,200 TD) can still draw upon special funds available for this purpose (PP, FSN, or voluntary citizens' rural development fund).

The State, through its various programs, assumes the balance of investment costs not covered by the STEG or beneficiaries. The State's contribution now accounts for up to 85% of total project connection costs, compared to 45% in the program's early years. The practical nature of this subsidy is that by contributing lower subsidies in earlier years, this public utility was encouraged to build a system that would provide them with greater revenues in the early years of the program. As the system expended, this base revenue resulted in less financial burden on the company.

Sustainable Financial and Tariff Strategies

For long-term sustainability, a rural electrification program must establish a system of tariffs and charges that are self-financing and do not depend on increasingly larger subsidies from State revenues. In this respect, Tunisia's tariff policy has avoided many of the pitfalls encountered in other developing countries. STEG prices power close to its long-term marginal cost, and makes considerable efforts to keep rates in line with the cost of providing electricity.

The tariff structure, negotiated between STEG and the MI, reflects the differing costs in providing electricity supplies to broad customer groups (Table 7.4). Thus, tariffs are lower for high-voltage (HV), industrial customers with high consumption levels and higher for LV customers, who typically are households with low levels of consumption. On the other hand, differences in costs of delivering energy based on location are not reflected in current tariffs. Thus, tariffs are established on a national basis without taking into account, for example, the considerable cost differences in supplying rural and urban households. In this regard, rural household tariffs benefit from a significant cross-subsidy since each new connection costs significantly more than the STEG bills.

According to a STEG-requested tariff study conducted in 1996, high- and medium-voltage tariffs, on average, reflect marginal costs of supply. However, low voltage tariffs were about 10% lower than their long-term marginal costs of supply, despite their being generally higher than high- and MV tariffs.

Table 7.4. Average Price of Electricity (Excluding Taxes), by Consumer Group, 1994–1999 (millimes* per kWh)

	Year					
Voltage Group	1994	1995	1996	1997	1998	1999
High	42.3	43.9	43.4	43.7	44.0	44.2
Medium	56.7	58.5	58.7	58.7	58.5	58.6
Low	74.0	76.2	77.1	76.9	76.9	76.7
Average Price	61.1	63.1	63.7	64.0	64.1	64.5

* 1,000 millimes = 1 TD

A second characteristic of the tariff structure is the distinction between peak and off-peak usage in all electricity markets (Table 7.5). In many cases, peak-hour tariffs are nearly twice as high as off-peak tariffs.

The low-voltage supply, of which rural users account for 11%, has various tariffs designed to promote social equity and rural development. For example, a low lifeline tariff applies to consumers who use less than 50 kWh per month. These consumers pay 63 millimes per kWh for the first tranche, which rises to 90 millimes per kWh for consumption of more than 50 kWh per month. The progressive nature of these tariffs encourages consumers to manage their consumption in order to reduce consumption in the next higher tranche. Public lighting, which ensures greater public security, benefits from a special tariff.

STEG tariffs are also designed to promote rural development, especially agriculture. Thus, irrigation benefits from the lowest tariffs (Table 7.5). A low off-peak tariff (35 millimes per kWh compared to 45 millimes per kWh) encourages farmers to irrigate at night. Since the early days of rural electrification, tariff policies have particularly encouraged two activities: oil pressing and milling/grinding. Until 1978, each activity benefited from its own tariff, which was substantially lower than the average low-tension tariff. Between 1979 and 1993, the two tariffs were combined into one that was still lower than the average.

Table 7.5. Electricity Tariffs (Excluding Taxes), 2001

		Fixed Charges[1]		Energy Price (mill/kWh)[1,2]			
Voltage Level	Tariff	Subscription (mill/customer/month)	Power (mill/kW/month)	Day	Peak	Evening	Night
High tension	4 times a day	-	2,500	42	82	63	29
	3 times a day	-	2,500	44	80	NA	30
	Back up	-	1,000	53	95	68	31
Medium tension	Uniform	-	300[3]	65			
	Time of day	-	3,000	50	94		
	Water pumping	-	3,000	51	93		
	Agricultural use	-	-	50	Out		
	Pumping for irrigation	-	-	50	Out		
	Back up	-	1,500	63	102		
Low tension	Economic tranche[4] (1 and 2 kVA)	-	100[3]	63			
	Normal tranche (> 2 VA)	-	100[3]	90			
	Public lighting	-	200[3]	77			
	Water heating	400	-	66	Out	66	
	Heating and cooling	300	-	98			
	Irrigation						
	Uniform	300	100[3]	61			
	Time of day	700	-	45	Out	NA	35

[1] A value added tax is applied at the following rates: 18% on all fixed charges and on the energy price (taxes excluded) for all uses except domestic and irrigation; 10% on the energy price (taxes excluded) for domestic and irrigation uses.
[2] A municipal tax is applied at the rate of 3 millimes per kWh.
[3] millimes per kVA per month.
[4] Below 50 kWh per month; above this, the normal tranche applies.
mill. = millimes. NA = not applicable.

In 1994, however, in an effort to simplify, this tariff was aligned with the average low-tension tariff. These advantageous agricultural tariffs are part of a broader program to stimulate rural development, which also includes low-interest loans and subsidies to such projects as irrigation, storage centers for agricultural products, milk-collection centers, and rural industries (including repair shops, bakeries, hairdressers, and weaving sheds).

Unlike tariffs in many developing countries, Tunisia's tariffs are frequently increased in order to preserve the utility's financial balance. Since 1992, five increases have occurred (7% in 1992, 3% in 1993, 5.9% in 1994, 4.6% in 2000, and 2.4% in 2001), which have yielded an average tariff increase of more than 2% a year. However, this is substantially less than the 4.6% cost-of-living increase and therefore represents, in real terms, a decline in overall tariff level. Tariffs for domestic consumers, including rural consumers, have declined more sharply than the average (by about 16% over the past five years). From 1991 to 2001, the price of the lifeline segment (less than 50 kWh) rose only 6 millimes per kWh, while tariffs for consumption above 50 kWh rose 20 millimes per kWh (Table 7.6).

Although STEG does not provide sectoral accounts, it is believed that, over the past decade, the gap between electricity-sector costs and prices has been modest. During the mid-1990s, the costs of supplying electricity may have been somewhat higher than revenues; however, as fuel prices fell in subsequent years, STEG costs and sales revenue probably became aligned.

Table 7.6. Trends in Low-voltage Household Tariff (millimes/kWh)

	Year										
Tariff Level	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Less than 50 kWh	57	59	59	61	61	61	61	61	61	62	63
More than 50kWh	70	76	79	83	83	83	83	83	83	87	90

Overall, STEG's finances are healthy, with only moderate debt. However, in its accounts, STEG does not distinguish between net profitability of its electricity and gas activities. In the mid-1990s, it is probable that deficits in the overall electricity account were compensated for by gas profits. Although the electricity sector appears to have been in balance in the late-1990s, costs have subsequently risen. The price of oil, which accounts for a substantial share of generation capacity, increased sharply, and the cost of connecting households remote from the grid continues to rise. At the same time, tariff increases have not kept pace with inflation.

Financing electricity deficits through surpluses in the gas account may be practicable for a limited period, particularly when gas prices are high. However, the process is vulnerable to changing conditions in the gas market, masking the true financial position of the electricity sector. This, in turn, distorts electricity-sector planning and adds to the political difficulty of raising tariffs.

Adoption of MALT—Cost-cutting Technical Innovations

At the outset of Tunisia's rural electrification program, it was clear that the only way to meet the program's ambitious goals would be to keep investment costs to a minimum. Early on, vigorous efforts were made to cut costs. In addition to STEG's pursuit of efficient operational and commercial practices, the utility's engineers have continuously developed and adapted technical innovations to Tunisian conditions, thereby reducing the costs of both implementation and maintenance.

While it is not possible to determine what proportion of Tunisia's rural electrification program has resulted from these cost-cutting innovations, the AfDB loan targets from 1979 to 1989 were exceeded by a large percentage for all three rural electrification loans (Table 7.7). In all AfDB loans over this time period, the length of 30-kV and LV lines, number of substations, and, most importantly, number of new connections far surpass specified targets. While, in 1979, a portion of the 72% greater number of connections was due to devaluation of the TD, the additional 78% new connections in 1982 and 52% in 1989 were certainly made possible by ongoing, successful reductions in costs. Thus, the costs reductions enable STEG to provide rural electricity service to a greater number of consumers.

Commitment to Customized Solutions

One key reason for these cost reductions was Tunisia's early adoption, in the mid-1970s, of a low-cost, three-phase/single-phase distribution system, known as MALT. Unlike most African countries and many other developing countries, Tunisia chose not to adopt the technical standards it had inherited from Europe, which included a three-phase, LV distribution system, suited to densely populated areas and heavy loads. Many developing countries that did adopt this system, following the advice of European utilities, ended up with a high-cost-per-km distribution infrastructure that was poorly suited to their scattered settlements and low demand levels.

Tunisia's decision to adapt the lower-cost, three-phase/single-phase distribution technology used in North America and Australia to its unique environment is arguably the single most important reason for the country's later success in rural electrification (Box 7.1). Wider use of single-phase distribution not only reduced costs dramatically, enabling electrification of far more households within the same budget, but it also fostered in STEG a unique esprit de corps that grew out of this courageous technical decision. Though much criticized at the outset, it was later proven correct and supported by the political establishment. Moreover, STEG gained confidence through solving numerous technical and related problems involved in setting up the new system. As a result, the utility was motivated to continuously develop and implement vigorous cost-cutting efforts and innovative technical approaches over the following decades.

Table 7.7. Targets and Achievements of AfDB Rural Electrification Loans to Tunisia, 1979–1989

Major AfDB Loans	*30-kV lines (km)*	*Sub-stations*	*Low-voltage Lines(km)*	*New Connections*
1979				
Target	500	175	280	17,400
Achievement	910	574	1,375	29,900
% difference	54	330	391	72
1982				
Target	860	616	605	16,110
Achievement	1,293	1,114	1,531	28,640
% difference	50	81	150	78
1989				
Target	2,810	2,800	3,900	61,000
Achievement	3,715	3,976	6,590	92,557
% difference	32	42	69	52

Box 7.1. Adopting the MALT System: Key Technical Decisions

The three-phase/one-phase MALT distribution system adopted in Tunisia consists of major arteries of overhead lines in three-phase, 30-kV, line-to-line voltage, with four conductors (three phases and one neutral wire) and secondary, single-phase, 17.32-kV, line-to-neutral voltage rural distribution overhead lines (two wires: one phase and one neutral).

If heavy loads are to be fed, then three-phase lines with four conductors are used. Fuse cutouts protect MV lines. Single-phase transformers give a secondary, phase-to-neutral voltage of 230 V (single-phase, LV lines), which is used by most rural customers. The distribution system is composed of robust materials and equipment that are easy to use and maintain.

When Tunisia adopted the MALT system, it made a second key technical decision: opting for a relatively high, single-phase 17.32-kV voltage, rather than the weak 3 or 5 kV of the North American model. The higher voltage was selected for the single-phase rural electrification overhead lines because of the long distances between villages and the nearest three-phase artery and to provide for future demand growth over the 30-year lifetime of the lines.

Steps Toward MALT: Technical and Economic Decision-making

When Tunisia's need to accelerate rural electrification became evident in the early 1970s, as indicated, STEG undertook a technical audit of distribution to assess existing distribution methods, of which there were only two: the North American approach (characterized by widespread use of single-phase lines, combined with a three-phase backbone) and the European approach (with extended three-phase lines throughout the service zone). This audit indicated that the predominant European three-phase system was not well adapted to Tunisia's ambitious program of low-cost rural electrification. Given the features of Tunisia's targeted population—low rural incomes, dispersed households, and consumption limited to lighting and basic appliances (mainly refrigerators and television sets)—it was clear that the cost of rural electrification could not be financed solely through tariffs and that limited resources should be invested wisely. This led the technical audit to recommend considering a new means of distribution, using single-phase lines.

The adoption of the new distribution arrangement certainly was not done without controversy. According to one Tunisian engineer who participated in the program, "Never had a technical recommendation raised as many debates and exchanges of points of view in STEG" (Essebaa 1994). The environment at that time was hostile to the changeover, according to a later AfDB report (AfDB 1995a), with opposition from both system operators and European partners. However, a technical study for the Master Plan for Distribution confirmed the audit's recommendations. To avoid pitting the European and North American systems against each other, the Tunisians called the new three-phase/single-phase distribution system Mise A La Terre, referring to MALT's grounding of the fourth neutral wire.

Having established technical confidence, the decision to change over became an economic question. Thus, economic studies were carried out in several stages during 1974 and 1975. First, a comparative study of distribution systems was carried out in seven typical villages, with positive results for the MALT system, which resulted in 30% savings. Next, STEG developed a computerized model—an innovation at that time—capable of comparing systems costs in 300 projects randomly chosen from those selected for the Vth Development Plan (1977–1981). STEG staff gathered basic field data on electricity consumption, length of needed medium- and LV lines, and estimated future number of customers (five years after electrification) for specific end-uses (such as lighting and pumping). Technical assumptions were made about installed power and voltage drops. After gathering the most realistic prices of electrical equipment, these assumptions were used to design and cost different scenarios to provide a range of results for both distribution systems.

Results of the model, using data from the 300 randomly selected villages, highly favored the MALT system, which projected savings of 18-24% overall. As Table 7.8 shows, the largest savings was at the MV level. Soon after these results were made known, in January 1976, the decision was made to switch to the MALT system.

Table 7.8. Estimated Savings of MALT System, Compared to Three-phase Distribution System, 1975.

Network Level	Cost Reduction (%)
MV network	30-40
MV/LV substations	15-20
LV network	5-10
Overall	18-24

Source: Essebaa, 1994.

Rapid System Conversion and Resolution of Technical Problems

Once this decision was made, the changeover occurred rapidly, testifying to STEG's analytical, planning, and logistical abilities. To the extent possible, existing equipment and materials were kept and integrated with the new system in order to save costs.

The system conversion consisted of two major steps. The first involved a changeover from the existing 4,000 km of 30-kV grid, consisting of installing neutral point coils in HV/30kV substations, laying the fourth neutral wire on the main 30-kV feeder lines, and replacing the constant time protections (relays and current transformers) with reciprocal time protections in HV/MV and ring main unit (RMU) substations. The second included the planning, designing, and monitoring installation of new construction (lines and single- and three-phase substations) in the MALT system. Both steps posed important questions of technical adaptation, organization, implementation capacity, and customer relations, given the repeated interruptions in supply which inevitably occurred during the changeover. Table 7.9 gives examples of the types of obstacles that STEG encountered during the conversion and how it overcame them.

Hydro-Quebec engineers provided technical advice on the three-phase/single-phase system, and short-term technical visits to Canada were organized for district chiefs and system operators and engineers beginning in 1976. However, planning of the new system and resolution of the problems encountered throughout the course of switching to the new system were entirely the work of STEG staff.

The changeover, which was completed in 1980, laid the foundation for launching a vast program of rural electrification in single-phase overhead branch lines. The length of single-phase lines rose from 0 km in 1976 to nearly 19,000 km in 2000. As the five-year plans were implemented, the number of kilometers of single-phase lines increased more rapidly than the number of kilometers of three-phase lines, and the single-phase investment grew increasingly dominant. Today, single-phase lines account for 51% of the total network, compared to only 16% in 1981. Similarly, the number of single-phase substations has risen from none in 1976 to more than 22,000 in 2000. Single-phase substations dedicated to rural electrification now account for 70% of all STEG substations.

Box 7.2. STEG's Switch to the MALT System: Typical Obstacles and Solutions for Changing from the 30-kV network

Obstacle	Solution
The European three-phase network did not easily accommodate a neutral fourth wire and difficulties were encountered in installing it on existing poles while maintaining the required height above ground.	For each type of crossing, considerable imagination and numerous trials and attempts were required to place the fourth wire accurately.
The neutral wire was attached to a LV spool insulator that was later judged inadequate, especially where excessively long spans between poles caused the wires to break.	The LV spool insulator was later replaced by a suspension insulator.
Wires snapped in some spans where the neutral wire had been incorrectly placed.	These anomalies were quickly corrected without significant damages.
The existing, fully saturated current transformers were not well adapted to MALT.	These were replaced with higher performance current transformers.
Difficulties were encountered that were linked to necessary power cuts in order to replace and adjust protections.	The tripping-reclosing cycles and the automates associated with the new protections were studied, identified, wired, and tested in the laboratory prior to installation. Field interventions were reduced to installation and connection of a fully equipped panel, wired, and tested in the laboratory.
Taking the resistant earth protection out of service created much apprehension.	With more experience, it was demonstrated that the resistant earth protection was not indispensable.
The new three-phase transformers created problems of tank overheating in cases of outages in one live-wire.	These were replaced by four-column, magnetic transformers.
The first fuse cutouts and the cabin substation crossing insulators were not suited to the humid climate of the coastal zones or the salinity of Chott El Jérid.	Technical specifications were modified to reinforce insulation of equipment installed in these geographical areas.
Disturbances were encountered in local telephone lines running along long-distance electric lines.	Disturbances were resolved by using filters on the telephone lines and by improving line groundings.

Technical Solutions for Large-motor Productive Uses

As the MALT system has advanced and proven its reliability and safety, criticism has diminished, but some negative points are still raised. Single-phase lines present no difficulties for household uses such as refrigerators or color televisions or small motors such as electric pumps or manual tools. However, adaptations and conversions must be made in order to serve large-motors above 7.5 horsepower, agro-industrial and deep-borehole irrigation loads. This is a potential problem for larger-scale industrial development in more remote areas, where rural customers must bear the additional costs.

Most industrial development occurs in industrial zones and incorporated villages, which are supplied with three-phase, 30-kV lines. Outside these areas, conversion from single-phase to three-phase lines can be made later, if justified by the load. However, in practice, this has seldom happened in Tunisia.

Technical solutions—widely marketed and practiced in North America—consist of special, more expensive motors, which, for 100-hp loads, can cost an additional US$2,000-15,000. These costs are minor compared to the cost of installing three-phase lines, and it has been recommended to use single-phase lines even in areas with high loads from agro-industry and pumping (Hicks 1993). In Tunisia, however, early experience with single-phase, 7.5-hp electric pumps was unsatisfactory, which created suspicion among consumers that single-phase lines were somehow inferior. STEG has developed several solutions for rural customers who own large motors. Still, these solutions are not widely practiced mainly because there are not many cases of large loads. In all cases, however, the customer must bear the extra costs.

It is difficult to determine to what extent unavailability of three-phase power lines has prevented establishment of productive, large-motor uses in more remote rural areas. In Tunisia today, it is not uncommon for prosperous retirees to return to their rural homes to establish economic activities. Two such examples were encountered in this study's informal rural appraisal: a vineyard and winery under construction had only single-phase connections and would incur considerable costs to purchase motors for both large-scale irrigation and pressing; and a proposed ostrich-raising project would require numerous electric heaters.

Continuing Tradition of Cost-reducing Technical Innovation

The successful adoption of the MALT system fostered STEG's aggressive approach to cost-cutting, technical innovation. Throughout the 1980s and 1990s, technical and economic studies and pilot projects were undertaken to further reduce distribution-system costs. These resulted in a number of changes and cost savings, of which examples can be given (roughly in order of importance of cost savings): replacement of copper wiring with aluminium alloy; pin insulators replacing suspension chains; cheaper, lighter round iron poles; fuses rather than circuit breakers; less expensive meters; backfilling rather than concrete foundations around poles; and mixed MV and LV network. Standardization of equipment and procedures were pursued, mainly to improve quality of service and reduce network losses, but these changes - such as the replacement of spark gap by lighting arresters, the introduction of three-phase transformers, and the development of a distribution-system construction guide - resulted in cost reductions as well. Stock management (on-time delivery) and bulk buying methods were also used to reduce costs considerably.[3]

STEG has continued to reduce distribution-system costs through further innovations. These include the Single-Wire Earth-Return (SWER) and the MALT 4.16-kV, single-phase line. SWER, a variation on the MALT system, was introduced in 1990. It has only one live wire and no neutral wire. Instead, the return current passes through at a grounding point at the end of the line (the MV/LV substations). The technique allows an additional cost reduction of 26-30%, compared to single-phase MALT (according to a 1996 study on village cases). SWER was introduced with a number of precautions because of the potential risks of the returning current to humans and animals if lines are not carefully installed and monitored.[4] By late 1996, the feeder lines implemented using SWER as pilot projects supplied 425 villages through 1,148 MV/LV substations. District chiefs have the freedom to decide whether to use SWER in specific rural electrification projects.

The MALT 4.16-kV, single-phase line can reduce the costs of electrifying rural villages in which houses are widely dispersed. It is natural that as the rate of rural electrification increases, the number of locations with groups of houses decreases. The remaining households without electricity are more scattered, resulting in higher average cost per customer. This technique also is suitable only for the relatively few projects at the end of the network, where no further extensions will occur. Hence, the gains are relatively small and usually unjustified by the increased management needs of introducing another level of voltage and range of network materials. Nonetheless, district chiefs have the option of choosing to use the 4.16-kv, single-phase line for projects with widely scattered households at the end of the grid.

Thus, the attempts to reduce the costs of rural electrification in Tunisia have been widespread. The company executing the rural electrification program could have taken the conservative approach of overbuilding the systems, as has occurred in many others countries. However, this would have dramatically increased the investments needed to complete the program.

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[3] Though the savings of any one innovation may be relatively modest, the cumulative effect is considerable, testifying to the importance of STEG's culture of continuous improvement.

[4] The disadvantage of SWER is that a more extensive and costly grounding network is necessary at every point where the line is grounded, as the voltage drop at the grounding points could be sufficiently high to shock livestock or humans who accidentally touch the line. In Tunisia, SWER is used in more remote areas, where loads are usually low; hence, the voltage is low and less dangerous. Nonetheless, given the increasing loads in remote areas, effective grounding will need to be carefully monitored in the future.

Photovoltaics: Complementary Strategy for Isolated Users

Tunisia's national PV program underscores the country's commitment to provide at least a minimal level of electrification service to even its most remote rural households, which otherwise would remain unconnected. Interest in PV developed during the early 1980s, based on environmental and social grounds. Several demonstration projects were followed by pilot dissemination projects, which showed that the technology could contribute to meet the basic electricity needs of isolated rural households. Often individual PV systems are more cost effective for providing electricity to isolated households than centralized systems, biogas, or grid extension.[5]

As indicated, currently, 7,750 households (about 1% of total electrified rural households), 200 schools, and a few clinics and forest/border posts have PV installations. The grid and PV programs are complementary. PV systems give basic electricity service, including lighting, television, and radio, but is not feasible for activities that require higher power requirements such as irrigation and refrigeration. For those households with minimum electricity requirements, PV has become an interesting alternative to the grid. At a connection cost of 1,900 TD per household, PV compares favorably with grid-connection ceiling costs of 1,500-2,200 TD, or even 2,500 TD for FSN projects.

Tunisia's PV rural electrification program has sought to meet user needs in several ways. First, system sizes have been increased, initially from 50 W to 70 W, with the present standard now at 100 W, in recognition of greater power needs and less insolation during winter. This equipment feeds a continuous 12-volt current: three light bulbs, one black-and-white television, and one radio-cassette player. Still, surveys have shown that the daily consumption level—up to six hours per day for lighting and television viewing, and three hours for radio-cassette player use—is 300 Wh. Households regularly overload their systems, sometimes leading to regulator-induced outages to protect the accumulator battery. To avoid such outages, users connect their televisions directly to the battery, resulting in further damage.

ANER rather than STEG is the implementing agency for the PV program. ANER has principal responsibility for Tunisia's renewable energy policy and promotion, and the Ministry of Economy, in 1993, designated ANER to play the lead role in PV rural electrification. Since then, ANER's implementation role has continued. Though the roles of STEG and ANER differ, their work is closely coordinated by the CNER, under the ægis of the General Directorate of Energy, which includes representatives of the Ministries of the Interior, Economic Development, and Environment; FSN; as well as STEG and ANER.

In Tunisia, electricity is viewed as a minimum public service to which every household has a social right. More than 90% of the country's PV rural electrification program is subsidized. Beneficiaries are required to pay 100 TD per system, with 200 TD financed by the regional government, and the remaining 1,600 TD financed by State

[5] Major projects included the GTZ-funded project in Kef and a State-financed rural schools program.

sources. Currently, consideration is being given to increasing the amount that beneficiaries pay since 20% of system costs today would equal 500 TD (100 TD represented 20% in 1990). The largest funding sources are PV-module exporting countries, which have provided supplier credits for some 50% of the PV systems installed to date. The World Bank has provided loan credits for another 25% of installed systems; while national development funds, NGOs, and beneficiaries have contributed the remainder. Clearly, the success of national PV rural electrification depends heavily on the availability of credits and subsidies.

Thus, rural electrification in Tunisia will reach even the most remote households in the next 10 years. Because the cost of serving them with grid electricity would be extremely expensive, policy makers in the country decided that it would be best to provide electricity to remote populations with PV systems.

Lessons in Integrated Rural Development and Social Equity

The lesson of the Tunisian rural electrification program is that the goal of provision of electricity services to widely scattered rural populations in Africa is certainly achievable. The Tunisian program has done many things right in its quest to have its rural population to enjoy the benefits of electricity. The national government has provided a long term stream of financing for a program that was integrated into its rural development strategy. The company carrying out the program decided early on to treat rural electrification differently than their urban approaches, and developed both technical and marketing strategies to deal with potential problems. So what are the reasons for success in Tunisia?

National Commitment. Tunisia's rural electrification achievement has been motivated by continuing national commitment as part of a broader, integrated rural development program that has emphasized social equality. Since its independence from France in 1956, the country has been at the vanguard in promoting human resources development, particularly gender equity. This is evidenced by the PSC that was promulgated immediately after independence and the IVth Development Plan, implemented in 1972, whose three pillars were basic education (for girls and boys), improved health services (with an emphasis on family planning), and rural electrification (whose socioeconomic criteria included gender equity).

Integrated Rural Development Context. Regional planning processes and successive five-year plans have tightly incorporated rural electrification into broader integrated rural development program, and this has produced synergistic effects. It is well known that growth in rural electrification and national socioeconomic indicators are strongly correlated. But in addition, informal surveys in several rural areas attest to the multiple benefits of rural electrification as perceived by rural households, and especially women. These include education, health and family planning, economic opportunities, and enhanced security. Also, integrating gender equity into the socioeconomic criteria for rural electrification has been a key factor in State support for and subsequent success of rural electrification.

Effective Institutional Approach. Regardless of the structure or process that a country adopts for rural electrification, certain principles are essential to success. These include well-defined, coordinated roles for all agencies concerned and established procedures that ensure agency cooperation that is perceived as being fair. The Tunisian system scores well on both counts. All agencies that participate in Tunisia's rural electrification program have well-defined roles. Coordination is ensured through an agency with a specific mandate for coordination. Equally important, policymaking and implementation agencies at both regional and national levels collaborate closely. Agency cooperation is facilitated through a project-selection process that is meticulous, orderly, and transparent. Through this process concerns about social justice are addressed, thereby reducing political pressure in identifying projects, allowing for a more rational and economic long-term program.

Well Managed and Innovative Utility. STEG's effectiveness and efficiency have earned it both political and popular support. Much of the utility's success can be attributed to a clear mandate and a management structure that combines the benefits of centralized planning and design with decentralized operations. Published norms, guidelines, and standard contracts contribute to operational transparency. STEG's implementation of commercial practices (including control of non-technical losses, billing, and collection practices) has been outstanding. Despite difficulties of delivering bills to isolated communities and their limited means of payment, rural consumers have an excellent payment record. Success factors include a customer management improvement program that has focused on sound meter-reading policies and practices, development of an integrated billing software program, and spreading out connection-cost payments. Successful construction and implementation of rural electrification projects owes much to encouraging private-sector participation in construction and promoting local-industry efforts to supply equipment and materials.

Lowering Costs of Rural Electrification. STEG has demonstrated a high-level capacity for adapting technology to meet Tunisia's clearly-defined, rural electrification objectives. Early on, the utility computerized its management systems and developed customized software applications, including a sophisticated inventory management system. Introduction of the MALT three-phase/single-phase distribution system has dramatically demonstrated STEG's high level of innovative technical expertise. Indeed, the utility's switch to the MALT system has been the single largest change introduced into the Tunisian program, permitting rapid expansion of rural electrification. In addition, the MALT system has provided a high level of service by reducing the rate and duration of outages.

Effective Tariff Policy. Tariffs broadly reflect the varying costs of supplying high-, medium-, and low-voltage customers. All markets distinguish between off-peak and peak usage to encourage more efficient capacity use. LV supply, of which rural users account for 11%, has various tariffs designed to promote social equity and rural development. These include a lifeline tariff for those who consume less than 50 kWh per month, subsidized public lighting, and low tariffs for irrigation. Such tariffs benefit from a significant, yet apparently manageable, cross-subsidy. Although STEG does not publish detailed power-sector finances, it is believed that, over the last decade, there has been only a modest gap between electricity-sector costs and prices.

Complementary PV Strategy. Tunisia's high-profile PV program—with its goal of providing a minimum 100-W level of electricity service to all households by 2010—reflects a commitment to including even the most remote rural areas in national development. The program features the high-quality technical support and robust finances that have characterized the country's rapidly expanding grid program. Success factors have included close institutional coordination with STEG; careful selection and adaptation of equipment; strong domestic and international donor support; and an emphasis on user needs, maintenance, and after-sales support.

Conclusion

Africa has the lowest rates of rural electrification in the world. In most countries the rates are 10 percent or less. In contrast, Tunisia's achievement of 100% urban and 88% rural electrification is remarkable, all the more so because the country's definition of rural electrification is restricted to connections made outside incorporated areas. Tunisia's rural population—although only 35% of the total population—is highly dispersed and isolated, with long distances between small groups of often scattered houses. This has led to many technical and managerial innovations. But the question also arises as to whether the considerable technical expertise of STEG and its related partners can be shared with other rural electrification programs in African.

In this regard, the MALT system has attracted the attention of various African countries. Both Senegal and Mali have sent their technicians to STEG for training or to obtain information that they can potentially apply in their countries. At the request of Madagascar's Ministry of Energy, STEG carried out a study for a pilot project in that country, and technicians from Madagascar's utility have participated in STEG training courses. Most of the STEG assistance in Africa thus far has been highly technical, on the MALT system and on electricity pricing. However as this review shows, a number of institutional, structural, financial and political factors have also played an important role in the success of the Tunisian rural electrification program. Indeed, encouraging STEG's technical assistance to rural electrification programs throughout Africa and to other developing countries worldwide—through both bilateral and multilateral programs—is an interesting option.

As total rural electrification rapidly approaches, Tunisia still faces many new challenges. Changes toward democratizing Tunisian society may create pressures for greater consumer participation in sectoral decision-making and the need for better communication between STEG and its customers. While in theory, Tunisia's project-selection process is transparent and minimizes political pressure, in practice, it may be criticized for verging on the mechanical. This is especially so in cases where local costs diverge from the national averages used to estimate the total costs of rural electrification. Finally, as electricity is provided to the final 12% of the rural population without it, the respective roles of the institutions providing PV systems and grid electrification will require clarification and improved coordination.

Despite these challenges, the program in Tunisia with its emphasis on coordinating access to electricity access with rural development has been quite a success. The political and socioeconomic conditions that have contributed to this achievement may not be replicated in other countries. Experience of the utility and the solutions to problems that it faced throughout the last 30 years may not provide a precise blueprint for other countries, but nonetheless, they certainly can provide useful insights. The accomplishments of the program in Tunisia may be a beacon for other countries that want their rural populations to have the modern benefits of electricity, but are having difficulty figuring out how to approach such an important long term commitment.

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