Reaching universal energy access in Morocco:

A successful experience in solar concessions

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Executive Summary

Ten years after the conclusion of its universal energy access program, Morocco has now become one of the best examples of successful integrated utility-led electrification programs. In less than fifteen years, rural electrification rates in the kingdom skyrocketed from a bottom low of 18% in 1990 to nearly 100% presently. Around 10% of the country's population, or 200,000 households living in remote rural areas, were electrified through solar home systems. Morocco is currently Africa's only success story in scaling up solar-driven electrification programs wherever grid extension programs were not feasible—not a small feat when one considers that it was not until the late 2000s that solar finally gained traction continent-wide with the emergence of so-called "pay-as-you-go" business models.

Three key factors have underpinned the dramatic success of the Moroccan experience with solar. First, a strong political support in favor of solar systems, which translated into ambitious agendas and adequate public resources to achieve government objectives. Second, the ability of local stakeholders to design and implement solar concessions and attract capable international solar developers on the basis of extensive pre-feasibility analyses that match demand estimates with various possible supply options through solar systems. Third, the ability of the national utility and solar concessionaires to leverage all possible sources of funding available for energy access around a transparent and financially sustainable private sector-driven model, from cross-subsidies to direct public subsidies and international debt (Nygaard et al., 2016 and Debeugny, 2017).

The Moroccan case demonstrates that solar systems hold potential in closing the electrification gap and electrifying the last percent of unelectrified households on reasonable financial terms. However, several factors call for prudence as one may be tempted to generalize key success factors for universal energy access in African contexts. Morocco started out with a rural electrification level which was far below those of its comparable neighboring countries. It had – and seized – the opportunity to exploit a high level of cross-subsidization from urban consumers and greatly benefited from an economic development level far exceeding that of most SSA countries. While the Moroccan experience may then well confirm the potential of solar to reach universal energy access, it seems important not to relate the dramatic increase in electrification to the implementation model alone and to rather contextualize the Moroccan experience in the light of the specific challenges that faced the country throughout its electrification process.

General context

Since the World Bank-driven liberalization of African power sector in the early 1990s, energy access policies have followed two different models. The main model, developed by the Bank, relied on the creation of so-called State-owned rural electrification agencies responsible for the design and implementation of national electrification programs through support to private enterprises and local cooperatives in providing electricity to rural populations, or alternatively—as in Senegal—through bidding processes in which local and international enterprises bid to overtake larger regional concession areas.

However, a few African countries—among them Morocco and Tunisia—decided to retain their national utilities and pursued a series of utility-led electrification programs in which national utilities are responsible for the implementation of energy access policy under the influence of then innovative technical, financial, and organizational approaches.

Morocco has followed a purely utility-driven approach, in which the national utility—the ONE, or *Office National de l'Électricité* (National Electricity Company) —has responsibility over the *entire* energy access program in the kingdom. Most importantly, and in a very unusual move compared to the model adopted in most African countries, the ONE was also responsible for providing electricity to remote communities (10% of the villages, 5% of the country's population), either through diesel- or renewable-powered mini-grids or through photovoltaic kits via a fee-for-service model coordinated by the ONE but operated by private companies under ten-year concession agreements (Nygaard et al., 2016).

Overall experience in energy access

Morocco has experienced a dramatic improvement in energy access rates over the past twenty years and has now become Africa's most celebrated success story in the sector. According to the latest estimates, Morocco's population totals around 35.7 million inhabitants, while rural and urban populations accounted for 13.6 million (38%) and 22.1 million people respectively. While the share of rural population has experienced a decline since independence, the number of rural inhabitants has increased by an estimated 1.9 million people over the same time period. Of the country's poor population 72% resided in rural areas as of 1987, which led the Moroccan government to engage in ambitious projects that aimed to reinforce access to basic merchant services in the late 1980s—including electricity—in underserved peri-urban and rural areas of the kingdom.

Back in 1990, rural electrification rates hardly reached 14% in Morocco; while Tunisia, Algeria, and Egypt had reached 70%, 80%, and 84% electrification rates on that year, respectively (Debeugny et al., 2017). After a couple of pilot-scale electrification programs, the Moroccan government launched in 1996 what has now become the Global Rural Electrification Program (*Programme d'Electrification Rurale Globale*, known under the acronym "PERG"), with the proclaimed objective of reaching universal energy access in less than 15 years (ONE, 1998-2015). Building on the lesson of previous pilots, the PERG relied on a series of technical, financial, and organizational innovations that paved the way for the first "integrated" electrification program. The most innovative feature of the program was its ability to leverage all possible electrification strategies existing at the time, with a strong emphasis on decentralized renewable options, on the basis of carefully designed operational, technical, and financial planning established for the entire country.

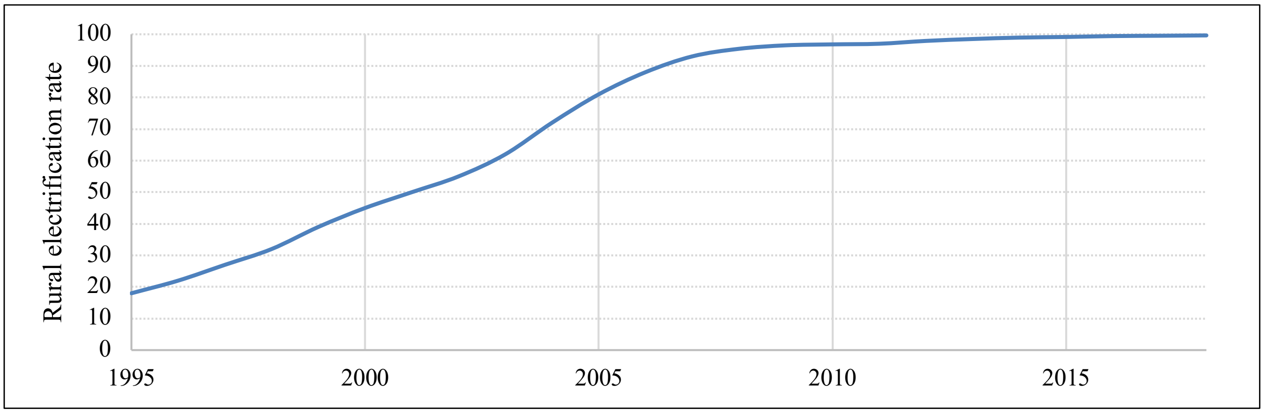

Figure 1. The electrification of Morocco: Reaching universal energy access in a decade (source: ONE)

More than twenty years after its inception, the PERG is now undoubtedly considered as a success. As of 2018, more than 40,500 villages have been electrified (37,100 through grid and mini-grid connection, 3,400 through solar kits) accounting for a total of around 2,078,679 households (grid connection: 2,027,120; PV solar: 51,559). The rural electrification rate increased by an average of 6% per year for more than a decade, up from 18% in 1995 to 95.4% in 2008 and 99.64% in 2018, for a grand total cost of around €2,5bn (ONE, 1998-2015).

Institutional structure of the national electrification plan

Universal energy access was the number one social policy of the Moroccan government in the 1990s and 2000s and gained very strong traction due to unconditional political support from the monarchy. While the main outcome of the power sector reforms in Morocco was the privatization of national power production and distribution in the major cities, the reforms of the Moroccan power sector did not lead to the creation of a rural electrification agency. Instead, full responsibility for implementing the PERG was left with the state-owned utility, the ONE. This "utility model" mostly stems from the limited success of early rural electrification programs of the 1970s and 1980s[1], during which the local authorities were fully responsible for financing rural electrification.

The ONE spearheaded the PERG as an integrated power company, a national transmission and system operator, a distribution company and a "single buyer" of electricity, owning 51% of the market share in final power supply, while local and smaller-scale municipal and private distribution companies supply the rest (Nygaard et al., 2016). To coordinate the PERG, the ONE set up a new, specially dedicated rural electrification department (*directorat*) that over time consisted of around one hundred staff members with previous experience in the power sector. The *directorat* was responsible for overall electricity planning, identifying villages, mobilizing local populations, supervising, quality control, and leveraging Geographic Information Systems (GIS) as part of the planning and implementation stages (AFD, 2012).

One of the key innovations of the PERG was to integrate off-grid electrification right from the outset as a systematic alternative to grid extension projects in remote and/or sparsely populated areas. After extensive

[1] The PERG was predated by the PPER, or *Programme de Pré-électrification Rurale*, which was the first African electrification program to integrate solar PV at scale. Results were limited due to lack of meaningful funding from local communities.

field surveys, solar home systems were the main option considered for the PERG on grounds of technical and economic feasibility, convenience in use, and the high levels of solar radiation throughout the country.

Definition of the perimeter of solar concessions

Solar electrification has been carried out using an integrated approach, weighting the pros and cons of grid and off-grid options under a single global program, namely the PERG, to ensure fairness in terms of advantages for the beneficiary and coherence in the electrification process. The assessment of needs in relation to rural electrification was undertaken throughout the country at the start of PERG using a first-of-its-kind survey campaign that aimed to cover 36,000 villages. Utility technicians visited each village to enquire about their geographical locations and delineations, populations, number of households and businesses, electricity needs, existing and necessary infrastructures, and existing social amenities in order to later establish least-cost electrification strategies at national scale.

In order to manage the large amount of collected information on rural households and villages, as well as economic, social, and electricity infrastructures, the utility used a GIS. The geospatial planning tool was used for rural electrification planning and cost evaluation, the spatial positioning of the villages throughout the country, and to evaluate the progress of the PERG. Grid extensions were planned first based on the principle of spatial optimization, with the objective to maximize village connections within the overall budget. Solar was then deployed wherever the grid could not go.

The master plan developed by the ONE relied on the assumption that the limiting factor in energy access remained last-mile connection, with the hypothesis that grid reliability and power supply would not be an issue—a hypothesis largely validated today.

In practice, the PERG was planned in five different stages (PERG 1 to 5). Each of the five main stages. would consist of the connection of households for which connection costs in the least-cost model would remain below a pre-defined threshold. According to an agreement between the ONE and solar companies, the ONE would be responsible for the connection of all households with connection costs below 27,000 Dh (around USD2,000 while off-grid PV solar would be offered as a default alternative to all remaining households. Given the success of the program and the fact that the 80% electrification objective had been reached six years ahead of schedule, the maximum threshold for grid connection was later increased to 50,000 Dh (around USD50) as part of the fifth and last stage of the PERG (c.f. figure 2 below) (Nygaard et al, 2016).

From a planning perspective, construction, operation, and management of infrastructures largely on the electrification mode: (i) for all grid-based projects, the ONE remains both prime/general contractor and is responsible for the exploitation of all assets; and (ii) for off-grid projects, the ONE organizes and controls the implementation of all electrification projects but delegates the execution and exploitation to private operators that are granted 10-year territorial concessions (*Délégation de Service Public* scheme, widespread throughout francophone Africa) (Massé et al., 2010).

Investment cost (Dh[2])			Grid connection		Off-grid solar		Final rural electrification rate
			Maximum connection cost per hh (Dh)	*Average connection cost per hh (Dh)*	*Connection cost per household (Dh)*	*Average cost per household (Dh)*	
PERG 1 & 2		1996-2001	10,000	6,500	N/A	N/A	18 => 55%
PERG 3		2002-2004	14,000	8,500			55% => 72%
PERG 4	**4-1**	2004-2005	20,000	12,000	6,000 to 15,000	7,000	72% => 87%
	4-2	2006-2006	27,000	17,000			87% => 96.8%
PERG 5		2009-Present	50,000	29,900	8,000 to 35,000	18,000	96.8% => 99.95%

Figure 2. Overview of the key parameters underlying the planning of the PERG (source: ONE, 2009)

Participation of the public and private sectors

Developing and implementing off-grid PV solar electrification programs at scale proved to be a daunting challenge for the ONE, a state-owned utility without experience in off-grid systems. Based on the key lessons derived from previous electrification programs implemented in the late 1980s and early 1990s, and in order to speed up the electrification process, to ensure a sustainable electricity service, and to integrate existing technical and organizational knowledge, the ONE decided to outsource the off-grid component to private-sector actors (SCRET-Maroc et al., 2005 et Massé et al., 2010).

An international bidding process was established to select enterprises for public-private partnershipss under 10-year concession contracts, and a first contract to supply 16,000 households with electricity was signed between Temasol (a consortium formed by Total and EDF) and ONE in 2002. A total of around 105,000 solar home systems has been contracted to date (*ibid*).

Terms of solar concessions and technical sustainability

The PPP concession contract set up the conditions for a fee-for-service model, according to which Temasol should install and maintain the installations for a period of 10 years on a territorial concession. The consumers pay a connection fee, as well as a monthly fee that depends on the size and the year of installation (this is, in a way, a version 1.0 of the pay-as-you-go business model made possible in the late 2000s by shrinking solar and LED costs, new M2M technologies, and the high penetration of mobile phones throughout Africa).

In the Moroccan public-private partnership model, the private service provider is in charge of: (i) marketing: identifying potential clients and generating demand; (ii) contracting: signing subscription contracts with the consumer on behalf of ONE; (iii) installation: buying and installing all PV system components; (iv) maintenance: delivering free of charge after-sale service and renewals during the 10-year warranty period; (v) revenue collection: collection of the connection fee and the monthly fee during the 10-year concession period; (vi) environmental control: maintenance includes changing batteries and recycling used batteries. Interestingly, the ONE remained the owner of all installations, and consumers were thus a customer of the

[2] 1 Dh ≈ 10 USD

utility itself and not of Temasol. These technical arrangements have ensured technical sustainability of the projects to date (Nygaard et al, 2016).

Upon the launch of the PERG in 1996, around 150,000 households were identified as having high costs for on-grid electrification and most suited for off-grid solutions under private sector leadership. This represented around 10% of households in rural areas and led to Morocco's electrification plan to become one of the world's most important solar-based electrification schemes at the time.

Accessibility and inclusivity

Morocco's national electrification plan required customers to pay for about 25% of the overall investment and electrification costs, while the remaining 75% were paid by the public sector. However, the terms and conditions for solar electrification slightly departed from national averages and household contributions typically varied from 13% to 85% of the upfront and monthly costs, depending on the system size (as detailed in figures 3, 4, and 5 below).

System	Household contribution		ONE contribution
	Upfront payment	*Monthly payment*	
50 W_p	700	60	5,400
75 W_p	1,800	96	5,400
100 W_p	5,000	129	5,400

Figure 3. Overview of the pricing scheme for Temasol's first solar project (16,000 kits; in Dh) (source: ONE)

System	Household contribution		ONE contribution
	Upfront payment	*Monthly payment*	
50 W_p	700	60	3,600 to 6,400
75 W_p	1,800	96	4,850 to 5,600
200 W_p	5,000	230	10,000 to 14,000

Figure 4. Overview of the pricing scheme for Sun Light Power's current projects (12,000 kits; in Dh) (source: ONE)

System	Households contribution		ONE contribution
	Upfront payment	*Monthly payment*	
75 W_p	900	65	Under negotiation
200 W_p	4,000	150	Under negotiation

Figure 5. Overview of the pricing scheme for Temasol's current projects (77,000 kits; in Dh) (source: ONE)

In total, 51,559 systems were actually installed by 2013—achieving only about 32% of what was first planned and about 50% of the targets in the concessions, due to unexpected grid extension initiatives under local population pressure (they perceived solar as a second-tier solution and an exclusive alternative that would prevent them from being ultimately connected to the grid). New solar projects signed in 2015 and

2016 with Temasol and Isofoton have brought this number to nearly 105,000 by raising the number of subsidies offered to households for high-capacity systems.

As solar projects extended further from urban and peri-urban regions and costs increased, subsidies were scaled up in order to ensure complete accessibility to the entire population.

Economic sustainability

One of the most important features of the PERG was to rely on long-term financing models to ensure sound sharing of responsibilities between end consumers, local municipalities, and the State-owned utility ONE. Twenty years after the inception of the program, the PERG still appears as a textbook case study for financially sustainable electrification programs that first leveraged all possible sources of funding, both locally and internationally, while preserving local sovereignty over energy access policy.

By 2019, consumers had provided about 25% of the total investment and ONE the remaining 75% for solar. The financial resources of the municipalities came from their value added tax allocation, as well as support from the ministry budget and the Municipal Development Fund. On the other hand, ONE drew most of its resources from a solidarity tax (2.25% of on-grid sales), concessionary loans, and equity. It is worth mentioning that customer and municipality contributions remained at their 1996 level throughout the entire PERG, thereby increasing the financial pressure on the ONE as grid connection costs gradually rose from 10,000 Dh/household to 14,000 Dh in 2002; 27,000 Dh in 2006; and finally, 50,000 Dh in 2009. In addition, solar electrification costs experienced a 150% increase over the same period.

The total cost of the PERG has been estimated at nearly USD2,5bn as of 2017, and its solar component at around USD350m over the same time frame.

While most financial resources were eventually available locally and provided at 75% by customers or ONE as equity, the PERG also relied on a fundraising campaign among international donors. Concessional debt and targeted subsidies, mainly aimed at achieving prefeasibility studies and setting up electrification planning programs, allowed the State to safeguard the financial viability of the project without endangering public finances. The figure below shows the breakdown of the different sources of funding of the ONE, which itself contributed to an average of 55% of the overall cost of the program.

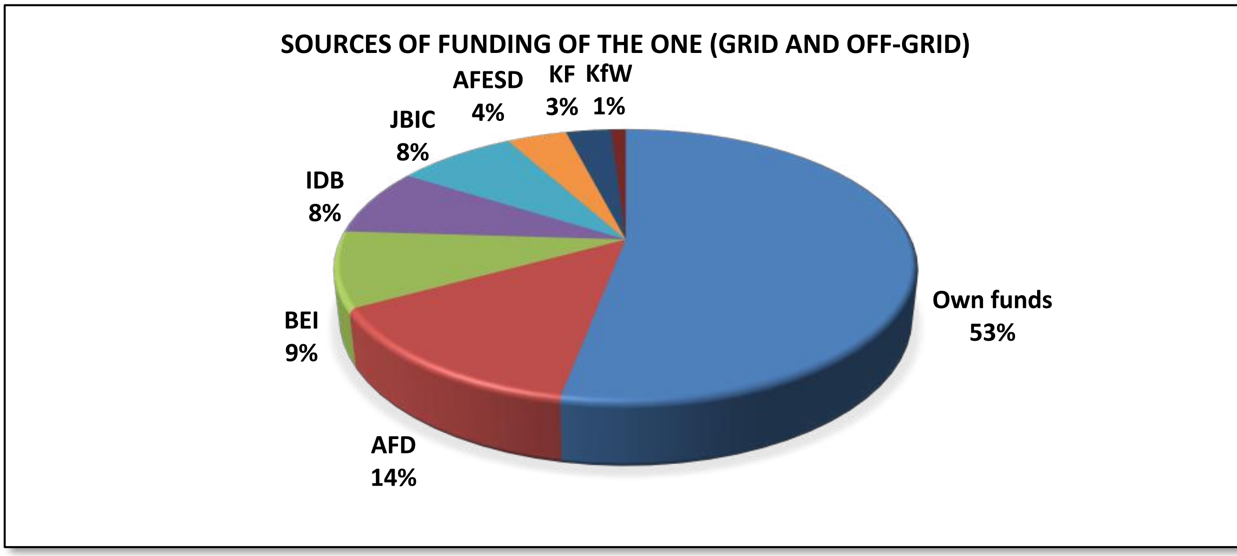

Figure 3. Main sources of funding of the ONE over the entire duration of the PERG (source: AFD)[3]

Evaluation and key lessons learned

Morocco's successful electrification has shown the potential of integrated utility-led electrification policies planned at national scale and was the first program to demonstrate the critical role of solar in bridging any gaps left by the national grid. One of the key success factors of the PERG has been to rely on an integrated planning approach leveraging all possible electrification strategies without dismissing solar as a credible electrification solution acceptable by local households. While traditional electrification programs had quasi-exclusively relied on grid extension as the sole electrification means, the PERG integrated grid extension and the diffusion of solar home systems into a grand national strategy aimed at harnessing the potential of all existing technologies to reach universal energy access on financially viable terms.

Connection costs and the demand estimation and forecast proved critical in the development of Morocco's national electrification plan. By conditioning the deployment of each electrification strategy to clear indicators relative to electrification costs and levels of demand, the PERG maintained a coherence between the various technical options for electrification (e.g., grid versus solar home systems) and the local demand and ability to pay, thereby ensuring a balance between *profitability* for power suppliers and *affordability* for local populations.

The gradual approach adopted in the PERG, and the division of the program into five stages, has played a key role in the monitoring of the solar program. It allowed the ONE to monitor progress via quantitative pre-defined targets and to leverage its increasing experience in electrification to further optimize electrification plans (demand forecast, ability to pay and pricing, concession contracts) with the support of international donors as the PERG unfolded. Significant efficiency gains and periodic updates of the electrification plan led ONE to electrify most of the last 10% of unelectrified households within the predefined public budget.

[3] **Acronyms:** AFD – French Development Agency; BEI – European Investment Bank; JBIC – Japan Bank for International Cooperation; IDB – Islamic Development Bank; AFESD – Arab Fund for Economic and Social Development; KF – Kuwait Fund; KfW – German Development Bank

Last but not least, Morocco's experience also demonstrates the potential of innovative financial schemes leveraging a range of instruments to finance integrated energy access policy. The controlled recourse to a range of bilateral and multilateral development finance institutions allowed the country to accelerate electrification and to retain sovereignty over its energy access policy while limiting the financial burden falling on public finances. As a matter of fact, the utility's ability to finance an average of 75% of the overall cost of the solar project (the remaining 25% being paid by consumers) allowed for the establishment of balanced and structured relations between public and private actors under the overall supervision of the national State-owned utility.

At the end of the day, the Moroccan experience not only confirms the potential of solar concessions backed by a national utility, but also provides interesting insights into the different strengths that other countries could leverage in order to electrify remote unelectrified households.

However, one should be careful in drawing parallels between country experiences. The development of a financially viable universal electrification plan was facilitated by the structure of the Moroccan market and the development level of the country. The program benefited from (i) a large potential for cross-subsidization between a growing base of urban consumers and rural users whose usage of electricity would remain comparatively limited[4]; (ii) a need for cross-subsidies that nevertheless remained limited, due to the relatively high ability to pay of rural households; (iii) the DISCO's good financial health and ability to offer direct subsidies for solar, since the distribution company was able to charge cost-reflective tariffs from the very inception of the PERG; and (iv) the financial health of the State, which eventually contributed to 75% of the overall cost of the solar project.

[4] The ratio "urban population"/"urban population" may not, in itself, be a reliable indicator of the potential for cross-subsidization. While the literature on the topic remains completely non-existent, one might prefer a more volumetric approach comparing loads; i.e., the power consumed (in MWh) by urban and rural populations to assess the effective potential for subsidization of electrification programs and power distribution in rural areas by urban and peri-urban consumers.

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