A New Framework for Rural Electrification Programs

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Background

Access to modern forms of energy is a key element for the development of human societies. The United Nations Energy (2005)[1] argues how this access is key for achieving the Millennium Development Goals. The International Energy Agency[2] highlights electricity as the most critical energy carrier for development. But in 2008 1.45 billion people worldwide didn't have access to electricity.[3] Electrification rates (percentage of households with access to electricity according to the World Bank's definition) amount to 99.8% in transition and OECD countries, but to only 72% in developing countries. Among these countries, low electrification rates are concentrated in rural areas (electrification rate of 58.4%, versus 90% in urban areas), where 55% of the population lives in the less developed regions.[4] In addition, in absence of vigorous policies, in 2030 1.3 billion people in the world will still live without access to electricity.[5]

Therefore, the need to foster electricity access in rural areas in developing countries seems urgent. However, this task is very complex; rural areas in developing countries are usually very poor and their inhabitants' per capita energy consumption is (as a cause and as a consequence) very low. Thus, the benefits of electrifying these areas would be low and risky for private companies[6]. In addition, households tend to be dispersed over remote and inaccessible areas, and the low consumption levels do not allow for taking advantage of the economies of scale present in the electricity sector. Thus, electrification costs are very high. This combination makes rural electrification activities (network expansion and operation, as well as possible investments in new generation capacity) very unattractive for private investors. This is one of the major underlying causes of low electrification levels in rural areas in developing countries.

On the other hand, access to modern forms of energy is in many countries a constitutional right, which makes government the subsidiary authority in charge of making sure that this right is fulfilled. This, added to the above-mentioned advantages for economic and social development, has led many governments to propose large investments in rural electrification, although it is difficult for them to cover the usually high costs. Therefore, it is necessary to involve private initiatives in the process; not only large multinational energy companies, but also small private arrangements such as cooperatives.

The sustainability of these installations is also a key aspect to be considered. Rural electrification programs should be based on a solid economic regime that provides economic sustainability for the installations. And they should also take into account environmental concerns, and ensure, through participatory instruments, social sustainability.

In this paper we propose a new regulatory framework for Guatemala by which governments would only provide the funds needed to make these projects profitable for private investors, closing the gap between the (low) expected revenues from consumers, and the (high) expected costs of providing the service. In addition, this new regulation must be integrated easily in the existing general energy regulation of the country.

A New Regulatory Framework for Rural Electrification

Basic principles for rural electrification programs

The development of the regulatory framework proposed required first the definition of basic principles on which to base it. The basic principles identified in this case were:

Universal access: The importance of electricity in sustainable development requires that all the population that demand electricity should have access to it in order to foster this development. This may imply the need for subsidies, given that the cost of supplying electricity to rural areas may exceed the capacity to pay for it.

Subsidiarity of the State in the electrification of rural areas: The electrification of remote areas, usually characterized by a sparse population, should be planned, realized and maintained first and foremost at the local level by local authorities, since these are closer to the needs of the population and know better their particular needs.

Local community participation: It is a right of the citizens to actively participate in political decision processes. This participation is particularly relevant in rural electrification, since its influence in the maintenance of the equipment is

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key to the sustainability of these programs. Educational programs to train the local population may be necessary.

Fair prices and reasonable quality: Although the quality of supply should be reasonable, it will seldom be possible to achieve the quality levels of those areas supplied by the grid. Therefore, the cost for the consumer of the electricity in rural areas should never be higher than the cost for grid-connected ones, as that would be discriminatory. Subsidies may be required to achieve this principle.

Promotion of private initiative and competition: As said in the introduction, the promotion of private initiative is crucial for rural electrification in order to raise the capital required. Competition will also help to achieve lower costs, and therefore minimise the need for subsidies

The elements of the proposal: translating the basic principles into the framework

This section describes how the basic principles identified are translated into the elements of a proposal for the regulation of rural electrification. A major feature of this proposal is that it is a service-based model, rather than investment-based, as will be described below.

Promotion of private initiative and competition

This would be achieved by a competitive tendering process, by which private investors would compete for the subsidies available for the electrification of the rural areas previously identified in a National Rural Electrification Plan. These subsidies, which should cover the gap between the costs incurred by the investor and the income received from consumers, would be released by the public administration according to the correct installation and operation of the equipment.

Under this scheme, a potential supplier must bid the minimum subsidy to be received for each connection point

Type of developers

Although this proposal does not specify the type of developers that should carry out the electrification projects, it is recommended that local ventures and communities are incentivized to participate in the tenders and in the maintenance of the installation, given their crucial role in the sustainability of the project.

Financial regime

Given that income will usually be lower than costs, subsidies will be necessary. These subsidies may come from different sources: other energy consumers, national budgets, advanced financing mechanisms like the Kyoto Protocol's Clean Development Mechanisms, or national, regional or international development agencies. However, in order to guarantee their availability, and also to decouple funding agencies or sources from investors, we propose the creation of a dedicated fund, which on the one hand aggregates the different sources, and on the other hand, guarantees its exclusive use for rural electrification.

In order to achieve the sustainability of the projects, subsidies must be released upon the provision of the service, and not associated to the investments. Therefore, subsidies will be paid to investors during the lifetime of the project, to deter "build-and-run" behaviors. This should be governed by a contract signed between the electricity provider and the public administration managing the subsidies. The disadvantage of this proposal is that, by deferring the grant, the contractor will need more funding, which means that only those agents who have borrowing capacity could engage in this type of competiton. This aspect should, therefore, be carefully evaluated.

The payment of the subsidies must be subject to the verification of the continuity and quality of the electricity service.

Electricity rates

Electricity rates must be calculated in reference to the existing social tariff for grid customers, and should never be above them. However, they must cover at least maintenance costs to ensure the financial viability of the project. Different rates may be set depending on the quality of service.

Ownership of the equipment

Being this a service-based model, the achievement of rural electrification should be measured in terms of the quality of the electricity service provided, rather than on the number of installations. This results in that the ownership of the generation equipment belongs to the supplier, rather than to the final users. This in turn places the responsibility for maintenance on the suppliers, which usually have expert

personnel, instead of on the final users.

Other elements promoting sustainability

The following elements are introduced to ensure the sustainability of the project, in addition to those previously described:

- The temporal scope for the regulation and the financial regime must always go beyond the investment phase
- The costs to be recovered must include not only investment ones, but also replacement, operation and maintenance costs during the lifetime of the installation.
- The user price for this service must be sufficient to cover maintenance, but should not exceed the social electricity rate for grid-connected users. Making users pay involves them in the scheme, makes them conscious of the cost of electricity, and makes them require a certain quality for it.
- Local administrations become the monitoring agents for the technical and economic terms of the electricity service, thus involving local communities and decentralizing the administrative process.
- A fraction of the dedicated fund must be devoted to training and education for electricity users.

An Application to Guatemala

Guatemala is the most populated country in Central America and at the same time the largest economy in the area. Nonetheless 57% of the population lives in poverty, 21.7% in extreme poverty. Seventy four percent is concentrated in rural areas and 76% is indigenous population. The electrification rate rose from 37% in 1990 to 84% in 2002. The major part of the electrification has been achieved via extension of the national electricity grid. Rural and mountainous areas have been left apart and are nowadays isolated. These areas are at the same time those with the highest poverty indices. The characterization of demand for housing, schools or medical centres was taken from Rafael Landívar University[7], CIEMAT[8] and own estimates. This framework would provide electricity to 700,000 people (6% of the Guatemalan population).[9]

The basic level of electricity supply has been set at 150 Wh/day. We have assumed that there is a school and a medical center for every five communities.

We considered three different configurations: home systems, battery charging stations, and micro grids. We examined various generation technologies: photovoltaic panels, diesel motors and hydro units.

Solar home systems have the advantage of the proximity to the user, low maintenance, and ease of installation. They do not need measurement devices as most of their costs are investment costs. In return, its low concentration may make the maintenance more difficult.

In principle the use of fossil fuel-based solutions such as stand-alone diesel generators was considered as not suitable. Although they can be attractive due to lower initial investment, the volatility of fuel prices could result in very expensive operating costs and could jeopardize the economic sustainability of the projects. From an environmental sustainability perspective, these systems are not a good option. However, the decision to include them has been taken because the main objective of this regulatory framework is electrification, not environmental sustainability (dedicated legislation exists in Guatemala for that purpose)

Battery charging stations allow aligning photovoltaic generation with the load. They also facilitate the maintenance of the system centrally. On the other hand, they show some problems of discomfort, as they require moving batteries from the docking station to the individual houses, and also entail a risk from the discharge of battery acid.

In general, micro grids optimize power generation, distributing it more efficiently within the community, while avoiding the drawbacks of battery recharging stations. The practical problem is that micro grids may need separated meters to control each consumer's consumption. Three possible micro grids have been considered: with photovoltaic panels, with hydro plants and a mixed one with photovoltaic panels and an auxiliary diesel generator.

For the economic evaluation we calculated first the cash flows over the lifetime[10]: 20 years assumed for each type of installation. The cash flow is considered as the difference between income and expenditure for each installation. Income is the result of the sale of electricity at the rate considered (which equals the current social tariff set in Guatemala for grid users). Costs are all payments of the investment or operation. Cash flows for individual systems (IS), for battery charging stations (BSC), for Microgrids (MG), for photovoltaics (FV), and diesel, hydro and mixed systems were calculated. Those for photovoltaic installations are shown in Figure 1. Starting from the cash flow for each technology, we determined the amount

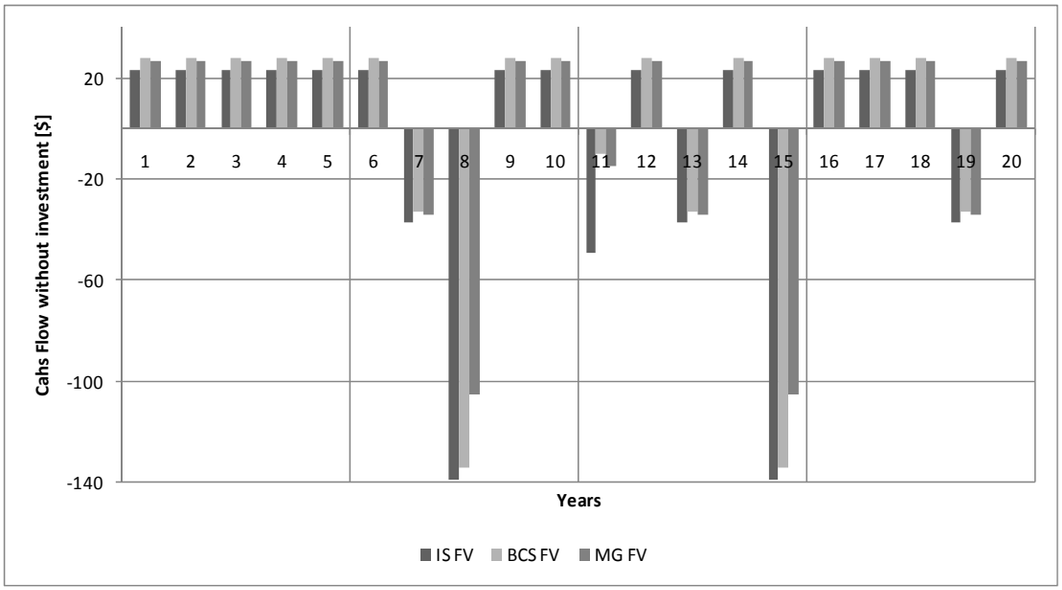

Figure 1
Comparison of Cash Flows of Different Systems

of subsidy required.

If we assume that the program would use 25% hydro microgrids, 25% solar home systems, 25% PV microgrids, and 25% battery recharging stations with PV, and we also assume a 20% overhead cost (which should cover training, dissemination and other administrative costs), the average cost of the program would be $111 million (net present value over the 20-year lifetime), or $804 per household.

The estimated income for the program (assuming the current social electricity tariff) is $30 million, or $216 per household (again, in net present value terms). Therefore, the subsidies required are $79 million, or $572 per household.

However, as mentioned previously, these subsidies should be spread over time. The initial subsidy would only be 70% of the investment cost, and the remaining amount would be paid in years 5, 10 and 15. If we assume that the total program will be developed in 10 years, the money to be paid from the dedicated fund would be the ones shown in the Table 2, for the first ten years.

The remaining subsidy to be paid would be $138 million ($61 million in NPV terms). As may be seen, this seems an affordable schedule for a country like Guatemala.

Year	1	2	3	4	5	6	7	8	9	10
Annual Expenses	4	4	4	4	4	6	6	7	8	8

Table 2
Expenses and earning rights from the dedicated fund (million US$)

Conclusions

This paper has presented a regulatory framework for the electrification of rural areas in Guatemala. The electrification program would cover around 137,500 households, or 700,000 people.

The objective of this new framework is to solve the current problems detected in previous rural electrification programs, basically access to capital, and the sustainability of electrification projects over time.

The new elements of the framework presented are: a service-based model instead of an installation-based one; a competitive tender mechanism to select suppliers, a dedicated fund to manage the subsidies, a temporal release of the subsidy that ensures the sustainability of the project, and the setting of a tariff that covers maintenance costs, but is never higher than the current social tariff for grid-connected users.

All these elements have been integrated in a single regulatory and economic model, which is expected to improve the sustainability of rural electrification projects in Guatemala, and, therefore, will contribute, from the electricity provision side, to improve living conditions in these areas.

The proposal is currently being studied by the Guatemalan government, and funds have already been secured from the Inter American Development bank. It is hoped that rates of rural electrification in Guatemala will increase very soon.

Footnotes

[1] United Nations Energy (2005). *The Energy Challenge for Achieving the Millennium Development Goals Energy and the Millennium Development Goals.* New York.

[2] International Energy Agency (2010). *The Electricity Access Database, World Energy Outlook*. Retrieved from http://www.iea.org/weo/electricity.asp.

[3] According to International Energy Agency (2010).

[4] United Nations Department of Economic and Social Affairs (2009). *World Urbanization Prospects. The 2009 Revision.* Retrieved from http://esa.un.org/unpd/wup/index.htm.

[5] International Energy Agency (2008). *World Energy Outlook 2008,* Energy and Poverty Slides. Paris.

[6] In fact, this is also the reason why network extension does not usually reach these areas, which have therefore been neglected largely in these programs.

[7] Rafael Landívar University, Guatemala (2008). *Caracterización de la Demanda de Energía en Zonas Rurales Aisladas de Guatemala* (Characterization of the energy demand of rural isolated areas in Guatemala). Final Report.

[8] CIEMAT (Centre for Energy, Environment and Technology) (2009). *Electrificación Rural en el Municipio de Cobán,* Departamento de Alta Verapaz (Guatemala) según el Modelo Intigis (Rural Electrification of the municipality of Cobán, Department Alta Verapaz, Guatemal). Informes Técnicos Ciemat 1160, enero 2009 (Technical Reports CIEMAT 1160, January 2009).

[9] This corresponds to the electrification of 137,470 households in 3,722 communities. These numbers are taken from note 8.

[10] For the calculations, an exchange rate of 7.5 Quetzales per U.S. dollar has been assumed. A discount rate of 12% is considered including the official interest rate of 7.5% in Guatemala (March 2009) plus a 4.5% risk premium.