IFA Biodiesel Project

Rural Electrification in West Africa

Industries For Africa Foundation
Ring Group
Sweden

"A curious thing about knowledge is the way it retrieves complexity into simplicity and the impossible into the achievable."

Background

It has been estimated that only about 20 percent, in some countries as little as 5 per cent, of the population of Africa has direct access to electricity. (Not including South Africa and Egypt). In rural areas this figure drops to about 2 percent. It is also accepted that it is critical for Africa to build facilities to provide power to those lacking it, especially in rural areas where most of the population live.

Rural electrification does raise a number of issues for African governments as rural communities often have low population densities and are situated in remote locations. The accepted wisdom of connection to national, or even regional, grid can therefore become prohibitively expensive and in many cases quite impractical. Various alternatives have been proposed that include a mix of wind power, solar power, micro hydroelectric, biomass and small diesel or petrol generators.

These plans, along with plans for central medium scale generating plants and transmission grids, all call for significant capital investment. Foreign loans used to pay foreign companies that would lead to little more than adding to the foreign debt of already debt burdened countries. The alternative of using private capital with western equipment would inevitably result in a service where few consumers could afford to pay at the rate necessary to ensure the viability of a profit driven company. More than 40 per cent of Africa's 600 million people live below the internationally recognized poverty line of $1 a day.

The Ring Group believes, quite simply, that to achieve electrification in those parts of the world that need it, the so called third world or developing countries, one must take a long hard look at the history of electrification in the developed world – how it developed before and what drove that development.

It could be said that electrical engineers and power generation equipment companies all over the world have a lot of skill but short memories. Most consider that electrification is a process that goes from large to small cities, and from small cities to rural areas. Few seem to remember that in most developed countries, electrification resulted from the multiplication of small local initiatives, small isolated systems that progressively connected into larger grids. Most generating systems were also built within the countries concerned thereby contributing substantially to their own economic and technological development.

Those few countries that successfully developed central electrical generating and distribution systems later, with public money and using imported equipment and technology, did so from an economic base that included strong export earnings from direct trade with the countries that supplied the equipment. New Zealand is a good case in point – during the decades immediately following World War II a large electrical infrastructure was built using equipment paid for from desperately needed agricultural exports to Europe where farming production remained devastated by the war for many years.

Another significant, if not generally realised, component for NZ was the ready availability of large numbers of earth moving and transport vehicles left behind by American forces using New Zealand as a jumping off point for various battles in the Pacific theatre of the war. These were pressed into service to build the power transmission system.

*Electrification in Europe and the US** *(Excerpts From Michel Matley www.marge.fr/pub/wemm.html)*

Some may know that electrification in Western Europe was largely completed in the mid-1930s, when only 10% of US farmers had access to the grid, and that rural electrification in the USA was only completed in the 1960s.

The rural electrification of France, a country paradoxically best known for its vast public utility EDF, was realised first through private investment, then through public investment and private management, and was in fact 95% complete by the time of nationalisation. Small enterprises, local governments and NGOs all played major roles in rural electrification in other European countries. In the USA, the cooperative movement filled a gap that neither private nor public utilities were much interested in plugging.

The major concern at the time was not at all between public or private property and management, but between centralised and local initiatives. European governments put the responsibility for electrification on local level authorities, bringing with it a growing support that made electrification possible in ever-remoter areas. US electrification created its later successes on the same principle through cooperatives. Both European and American administrations trusted the people, and did not presume to act in their name. This worked for a simple reason: nobody has a greater interest in electrification that those without access to electricity.

American rural electrification delivers further lessons. Firstly, that monopolies lead to excessive costs. The US electricity cooperatives successfully showed that they could be more cost-effective than the existing large private and public utilities and were able to cut costs by 30 to 50%. Secondly, they showed that having low tariffs was not a key issue. The US administration set up rules imposing minimum rather than maximum tariffs, generally at least 20% above those in use by the regular utilities, in order to protect the newborn rural cooperatives from local and political demagogy.

Another and crucial issue has now been widely forgotten by engineers worldwide. European electrification's history may well have been an early success, but it was a colourless and odourless one. It brought no more than a few bulbs, perhaps a radio and, very rarely, some productive equipment to farmers. Electricity itself raised little interest among farmers, unlike the arrival of piped water or the dissemination of domestic appliances for the farmhouse after World War II. American rural electrification, on the contrary, raised enthusiasm, because it came complete with many services that could and did change the farmers' way of life.

Following the example of the private sector, the US cooperative movement proposed a very different electrification model than the European one. Federal public funding not only came to develop grids but also to provide access to productive electrical equipment and domestic appliances, the latter by chance proving to be a far quicker and greater success. Rural electrification may have been nearly thirty years late compared with Europe, but farmers soon had equipment to match that in an urban household, and it took another thirty years for the European rural dweller to be in a similar position.

The reasons for these distinct approaches stem from the different economic and political visions. In Europe, most controversial issues in development were essentially related to colonisation. Right wing and left-leaning political leaders, industrial managers and Marxist opponents all shared a distrust of domestic, household markets. In the USA, on the other hand, the household market's potential was quickly recognised by marketing specialists and industrial leaders. In the electricity sector it was seen as an important issue and its development would largely mitigate the effects of the 1930s' economic crisis on the electrical industry.

This is one of the major reasons why US private industry ignored the rural market: while European governments focussed on spatial extension of the grid, the highly concentrated US electrical industry gave priority to upping its load factor. In order to improve their performance and benefits, the major players bought up promising appliance firms and concentrated utility development on sales to existing urban clients. Electricity cooperatives had the same concerns: they had to sell enough electricity to balance their accounts and repay federal loans. This had a considerable result: American rural electrification was far less costly to the public purse - relying mainly on soft loans while European electrification frequently involved 50% subsidies

In short - Third world women's access to washing machines may well be the true meaning of rural electrification – a process where electrical engineers and women have common interests, and should build innovative coalitions. This would be an alternative to the poor philosophy and trends behind today's mainstream electrification approaches, and one where gender specialists would have an important role to play: a women's electrification.

Ring Groups View

What is clear is the simple reality that electrification simply for the sake of supplying electricity to those who do not have it is both a pointless and an economically negative exercise. Certainly electrification can provide the means for many essential improvements to daily life of the people who don't have it. Those in the west, who take the ready availability of electricity for granted, can be horrified that millions live without it - but the fact remains it cannot exist without an economic base that can both afford to build it and afford to use it.

Every country in the developed world that has electrification either built their own generating systems or had sufficient earnings to pay similarly economically developed countries to supply them. Electrification is not a step to economic development – it is a result of such development - something that goes hand in hand with the development of productive industry, whatever form it takes.

Africa's industrial development – be it Farming and food processing, Mining and manufacturing or massive oil plantations and Biofuel refining, or all three - will go hand in hand with electrification. Along with this will go the development of the electrical appliances, electric tools and washing machines etc. That will take the demand for electricity to outside just that of those base industries. No developed country ever imported household appliances from countries with vastly higher labour costs than its own simply because it makes no economic sense to do so. All countries – be they first or third world – harbour opportunistic entrepreneurs that can quickly recognise and capitalise on any opportunity to make something locally if given the chance.

Those realities suggest the only practical way to approach the problem of electrification is to remember the lessons of history.

Conventional Central Power Plants vs. Distributed Generation

Conventional Central Power Plants

There are three major components in the cost of producing electricity; capital cost, operating cost and fuel cost. Electric power generation in the West is now dominated by large central power plants with electricity distributed to customers over a transmission grid. Factors that have led to large central power plants include:

- Economies of scale

Large and small power plants require the same level of complexity and instrumentation in order to operate reliably with good efficiency. This leads to a general trend of reducing capital and operating cost per kilowatt hour (kWh) of electricity produced as the size of the plant increases.

- Low cost of coal

Locally available coal is typically the lowest cost fuel, with mine site power plants producing the lowest fuel costs. Coal-fired power plants located at the mine site benefit from low fuel costs and decreasing cost per kWh with increasing size of the power plant.

- Government control of electricity market

Often the electricity market is under government control with fixed rate of return to the electricity producer. This guaranteed revenue lends itself to construction of large power plants with long payback periods. The electricity market tends to be controlled by one or two power generators.

- Existing Transmission Grids

Transmission grids for distributing electricity may already exist with their cost built into the regulated electricity rates. Even though the electricity loss in the transmission grid may be 3 to 6%, the existence of a grid reduces the capital cost of the user to obtain electricity. Rather than having to build his own power plant, the user merely pays the cost of connecting to the existing grid.

Equally Hydro and Nuclear power technologies lend themselves to construction of large-scale central plants. While small-scale hydro plants played a significant role in the earlier rural electrification of European countries – such a development path is dependant on the presence of abundant suitable waterways. Neither is particularly relevant to this discussion since the focus here is on how rural electrification develops and how that development can be duplicated in regions without incurring massive debt for large-scale plants.

Although central power plants can be reliable and cost effective, the efficiency of conversion of fuel energy to energy used is poor. Examples of stand-alone power plants and their energy use efficiency include:

- natural gas, oil or coal-fired steam cycle 30 to 35%
- natural gas fired gas turbine simple cycle 30%

- natural gas fired combined gas turbine-steam cycle 50%

Stand-alone power plants convert only 30 to 50% of the fuel energy to electricity while the remaining 50 to 65% is rejected as waste heat to cooling ponds or cooling towers. Inefficient conversion to useful energy also increases the amount of pollutants put into the atmosphere. Pollutants emitted by coal-fired power plants include sulphur oxides, nitrogen oxides, ash particles and mercury. Fossil fuels also produce carbon dioxide, a greenhouse gas that contributes to global warming.

Distributed Generation

Distributed generation is a term used for small power generators located near the point of electricity use as apposed to central power plants using transmissions grids. However as smaller scale power generation is usually less efficient at the production of electricity, the full benefits of distributed power generation are usually only achieved with cogeneration applications – especially if applied within an economic model that does not include the added costs of transmission grids.

Cogeneration (also combined heat and power, CHP) is the use of a heat engine or a power station to simultaneously generate both electricity and useful heat. Cogeneration is a thermodynamically efficient use of fuel. In separate production of electricity some energy must be rejected as waste heat, but in cogeneration this energy performs useful work.

In the 21st century, energy conservation has globally been highlighted due to an expected sharp increase in energy demands and the resultant increased pollution and global warming from greenhouse gases. The further demand for biofuel as a result of this is the major driving force behind the IFA/Ring Group Biodiesel project.

The establishment of oil plantations and refineries in areas of Africa that have little existing infrastructure and almost no electrification requires that these problems be addressed and solved if any progress is to be made.

IFA Biodiesel Project

This project requires the establishment of 100 individual plantations and refineries. Each refinery requires a constant and reliable 300 KW of electricity - 72000 KWH per day. They also require a supply of heat and steam for the refining process and they all produce a substantial quantity of biomass co-product – at least 25 tonnes per day each. To achieve the most efficient fuel production possible – and to achieve the net zero CO2 balance claimed for Biodiesel but rarely achieved – this co-product **must** be the energy source for all planting, harvesting and processing.

The energy content of this biomass is about the same as a low-grade coal and about twice that of peat – around 18 MJoules per kilogram. The 300 KW of direct electricity required by the refinery will therefore require the burning of about 4 tonnes per day of co-product, assuming a 35% conversion efficiency to electricity. Steam and waste heat from this cycle alone will meet all the other direct energy needs for the refinery thereby improving that efficiency quite dramatically.

A further use of the biomass is for the production of Methanol required for the transesterification of the oil in the refinery and as fertilizer for the plantation.

The biomass co-product can also provide the carbon feedstock for the smelting of iron ore for the construction of the tractors, alternators and prime movers required by the whole project. See (soon) the papers on Mining and Iron Smelting, IFA Tractors and Electric Generator Manufacture. It is not possible at this stage to accurately estimate the long-term steady usage rate for this aspect. Long term it will obviously need to be a balance found between Industrial demand for Iron and demand for Electricity.

Initially we could fairly estimate the availability of about ten tonnes per day per plantation of biomass fuel for the production of electricity for general use - giving a total of about 75 Megawatts capacity over 100 plantations. A simple duplication of the 500 Kilowatt refinery generating system for installation where the power is required - would require the additional construction of about 150 small generating stations.

The acceptance therefore of a distributed generating system as a first step toward electrification would require no particular capital intensive project – it would utilise technology developed already for the Biodiesel project – and most significantly would help create a solid base for industrial development and employment.

Transport of the fuel to the stations would need to be considered – however that could also be seen as a step to a more efficient communications infrastructure rather than a difficulty.

Most important perhaps is the fact such a distributed generating system would result in a situation very similar to that which provided the starting point for most Western Electrification.

Frank Williams Göteborg 2007-10-10
Ring Group
Sweden