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Thoughts on the 'ABC' model for rural electrification

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Abstract

The ABC model consists of building energy generation infrastructure designed to serve both anchor loads (e.g. cell phone towers) and rural, off-grid households. We see few realizable synergies in this model, and accordingly, few benefits compared with the alternative: dedicated energy generation assets for large loads and separate energy generation capacity for households.

The ABC model

ABC stands for Anchor-Business-Community; it is defined as a commercially viable private sector-led off-grid energy supply business model. Anchor (A) customers are located near a rural community and ideally provide a predictable daytime load while requiring a continuous supply of power. There are many kinds of possible anchor customers: telecom towers, petrol stations, agro-processing units, retail chains, mining companies, etc. Business (B) customers represent local commercial establishments for whom electricity is a critical input for expanding operations or improving productivity (retail shops, carpentry shops, irrigation systems, schools, clinics, etc.). Community (C) customers are primarily – but not exclusively – households that have a low and variable energy demand and that can be served by different types of energy solutions (rechargeable lamps and batteries, solar home systems, and micro-grids, among others).

Our current perspective on the ABC Model

While we have analyzed many businesses in the energy access sector, we have not been able to find a business that has succeeded in supplying electricity to a significant number of households sustainably (profitably) via the ABC model.

The initial appeal of the idea attracted many to try to implement it. However, we have come across several attempts that failed outright, or at best failed to provide the expected benefits and were therefore discontinued or not expanded to other sites. See this case study on DESI – one of the ABC-model champions – as a recent example: http://energyaccess.org/images/content/files/MicrogridsReportFINAL_low.pdf , page 53.

Therefore, our current perspective on the ABC model is that there are fundamental reasons why it is, in most cases, suboptimal to supply a large anchor load and several households from the same generation asset via a micro-grid. We outline them in the following sections.

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Higher transmission costs without compensating benefit

The ABC model would only make economic sense if it were cheaper to install all the power generation capacity in one location and build a transmission grid around it than to install power generation next to every customer (load) and thereby minimize all transmission. Moreover, the initial cost benefit, would have to be large enough to compensate for the losses caused by the transmission of electricity itself on an ongoing basis.

We found that in many situations, anchor clients are not directly in the middle of all household customers and in most cases the average customer will be further than 200m away from the anchor client. Cell phone towers, for example, are often located on hills near the village, not in the middle of a village. To cover distances larger than ~200m, electricity would require transmission at relatively high voltage (>48V) to keep transmission losses at an acceptable rate. However, even at a higher voltage, and independent of the transmission standard (DC or AC) as a rule of thumb, about 10-20% of energy will be lost as soon as it is transmitted for more than 200m[1], unless a significant amount of capital is invested in technology to improve the overall transmission efficiency.

Given the likely efficiency losses and the added infrastructure costs for cables and poles, we found that in most cases, it is not economically efficient to serve household customers and anchor clients from the same power source.

There are, of course, exceptions, for example if the power generation asset is already installed and under-utilized. In this situation, the additional investment in infrastructure and efficiency losses could be absorbed while still creating marginal gross profit. But then, we have not been able to find many underutilized assets, as should be expected.

[1] Consider that the losses from transmission decrease proportionally to the square of voltage: Losses ≈ const * (1/V^2), i.e. doubling voltage will reduce losses by a factor of 4. This is true for AC and DC current. From this perspective AC current has an advantage as it can be (i) transformed to a higher voltage easily and with few losses and (ii) at higher voltage it can be more easily managed (switched) than high-voltage DC current. From a pure efficiency standpoint, however, it is less obvious that one solution is better than the other: While the increase of voltage of an AC current is simple and relatively efficient, the conversion from DC current to AC current is often inefficient and/or expensive. The bottom line is that as soon as one has to transmit energy for more than 200m, losses of approximately 15% are likely with either DC or AC, unless the energy was generated in AC from the start, e.g. with a generator. This implies that at least 15% cost savings through synergies or economies of scale must be achieved in order to make the ABC model economically feasible. We do not believe this is generally the case.

Renewables in particular offer limited economies of scale

The ABC model could make sense if there are significant economies of scale on the side of the energy-generating asset. If two 5kW power plants cost significantly more than one single 10kW plant, it could be worthwhile to invest in additional distribution infrastructure and absorb transmission losses. However, if the combination of solar PV and batteries is an option, the economies of scale are relatively small. It makes more sense in this case to build several energy generation plants instead of one.

When a diesel generator is used, for example, the major concern in sizing the generator is the maximum power (W) required. If the maximum demand during the day would be 10kW, a 10kW (+reserve) nameplate capacity generator is needed. If this peak demand would only be required for a few hours every day, it would be reasonable to seek ways to use the generator for additional purposes outside of these hours. In such a scenario, the ABC model may work. However, Solar PV solutions are already competing with diesel generators in true off-grid locations for loads that could serve as anchor loads. And, if Solar PV is used, the equation changes in one important aspect.

Once solar PV, wind, or a combination of both is used to supply a load, the total energy required in the average intermittency period (i.e. on a daily basis) determines the size of the system, not the peak power demand. Hence the load profile, the variation of power demand during the day, becomes less relevant; the ability of the system to feed enough energy into the batteries, such that the energy demand can be met during an intermittent period, becomes the primary sizing factor as the load is basically driven through the battery.

Consequently, adding other loads, such as households, requires the proportional increase in the overall system capacity. And because solar PV system prices are almost proportional to their capacity, there is no economic benefit in installing one larger system – i.e. adding additional capacity in one place – over installing several smaller systems closer to the loads.

Supplying a business is different from supplying households with electricity service

There are two relevant consequences when supplying for businesses vs households – one relates to the cost of capital, the other is of a strategic nature:

Of course supplying a business – i.e. a mobile network operator like Vodacom – with energy services has a very different risk than supplying a rural household with energy services. In theory at least, the different business risks impact the cost of funding and the structure of such funding.

Generally, supplying an anchor client can be expected to have 'less risk' than supplying rural households. This should make funding more readily available and decrease financing costs for a business supplying commercial customers relative to a business supplying rural households. We have heard the argument that many small customers (households) could be considered less risky than a few large customers (businesses) but this would only hold true if there is a negative correlation between the individual customers, which is unlikely.

If supplying anchor client has less risk than serving households, capital should be cheaper for the former. In the absence of any correlation between anchor client and household risk, the capital cost for a combined business should be at least equivalent to the weighted average cost of capital of the two businesses. We say at least, because one could argue that the risk for a combined business is equivalent to its riskiest line of business.

In either case, the cost to fund an ABC model should be at least equal or higher than the cost to fund one AB and one C business of the same size.

Businesses specialize to provide an attractive product to a target market. A company that has succeeded in providing energy services to rural households would have to acquire a different expertise and experience (incl. contacts and relationships) to provide service to large anchor clients.

Different customer priorities may require different technology solutions

Anchor clients pay a premium for reliable service (acceptable downtime for cell-phone towers is <0.01%), whereas off-grid households want access to basic electricity services at a low cost. Especially if they pay for service rather than a subscription fee, reliability would still matter, but certainly less than for the anchor load. These different quality requirements may require different technologies – for example, with solar PV and batteries there is always the risk of prolonged periods without sun leading to a total depletion of stored energy. The village customer may accept the shutdown; the large Telco may not and therefore require a diesel back up system. This could make the solar installation too expensive for the Telco tower, but not the village.

The main advantages of renewable energy generation technologies (solar PV and wind) are that they can be installed in a decentralized manner without a significant increase in costs (i.e. there are few economies of scale in solar PV). In this context, we expect that in most cases, it will make more sense to install separate energy generation assets near each of the anchor client and the households. This goes so far that we believe the optimal approach to rural electrification is (i) to install micro-grids with many generation points connected to households, and (ii) to provide high-efficiency appliances to keep capital expenditures as low as possible. The result would be DC micro-grids where the distance between generation capacity and load never exceeds 150m and the average capacity installed per household remains below 100Wp (~500Wh) per day.

That said, we have come across cases where the ABC model did make sense and could anticipate certain limited circumstances where it would be worth exploring such a model in more detail:

1. **Grant funding or concessionary capital available for rural electrification** may make the combined system more attractive to the operator of the anchor load.
2. **Already-installed excess capacity at anchor client.** For example, a second generator, or an older generator with excess capacity, etc.
3. **Lowering maintenance cost through shared operations.** Note that this does not require a physical connection.
4. **Supplying nearby communities** may reduce the risk of vandalism or theft.