Green Power for Mobile

Community Power

Using Mobile to Extend the Grid

January 2010

Acknowledgements

This whitepaper has been developed by the GSMA with the support of Irbaris and Cairneagle Associates.

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Executive Summary

A significant opportunity exists to provide environmentally sustainable energy to people in the developing world who live beyond the electricity grid. And it is the mobile telecoms industry – which has already brought phones beyond the fixed telecoms grid - which holds the key to this next infrastructure innovation.

The Community Power Opportunity

There are 1.6 billion people in the world living without access to electricity. The mobile industry is experiencing unprecedented infrastructure growth in these same off-grid regions of the developing world. The GSMA estimates that nearly 639,000 off-grid base stations – the pieces of equipment which provide cellular network coverage - will be rolled out across the developing world by 2012.

Since mobile base stations need power to function, network operators have become adept at generating their own off-grid power. This has typically been achieved by running diesel generators at each site, although increasingly operators are installing renewable energy equipment, such as wind turbines and solar panels, to power their base stations.

The opportunity now exists for mobile network operators to provide electricity beyond the base station and into local communities, a phenomenon which the GSMA Development Fund calls "Community Power". Mobile network operators are trialling different approaches: at a minimum, operators can provide excess power to the community for small needs like charging up mobile handsets, large household batteries and rechargeable lanterns. At a maximum, the consistent power requirements of a mobile base station provide a stable "anchor" demand for a bigger investment by a third party company in a village energy system, powering both the base station as well as local homes and businesses.

In order to succeed, the third party scenario requires a strong business case, availability of suitable renewable energy resource and a favourable regulatory environment, all of which have been identified for India and East Africa.

Community Power is not just about social benefit; although that impact can be significant. It is also about improving the business case for off-grid telecoms by (a) growing revenue streams, (b) improving base station security, (c) charging mobile phones for increased usage, or (d) outsourcing power provision to third party companies to achieve lower cost of power.

Renewable sources of energy such as biomass and wind are suitable for Community Power solutions. GSMA research shows that biomass has the highest potential, due to its low cost of power generation and the availability of feedstock in off-grid areas. The GSMA forecasts that there is potential for 200,000 Community Power projects worldwide, which could provide sustainable electricity to 120 million people.

The GSMA Green Power for Mobile (GPM) Programme was Launched in September 2008 to 'Extend Mobile Beyond the Grid'.

The GPM programme, with its proven expertise in accelerating the installation of renewable energy solutions to off-grid telecoms base stations through pilots, technical assistance, case studies and Working Groups, is uniquely positioned to be a global knowledge centre enabling rapid replication of the Community Power model across the developing world. The GSMA now aims to work with key stakeholders to develop pilots using different technologies in different countries and also partner with development finance institutions to help provide financing for large scale deployment of the Community Power model.

To accelerate the formation of this energy ecosystem GPM calls on existing and emerging stakeholders to highlight their interest in this proposal, specifically:

- Operators and tower companies that are interested to pilot and move to full scale implementation of the Community Power model
- Vendors and energy companies that are positioned to provide off-grid, renewable power to both the base station and community simultaneously
- Financing institutions and development organisations that can facilitate large scale implementation of the Community Power model.

Interested parties should contact David Taverner at **greenpower@gsm.org**

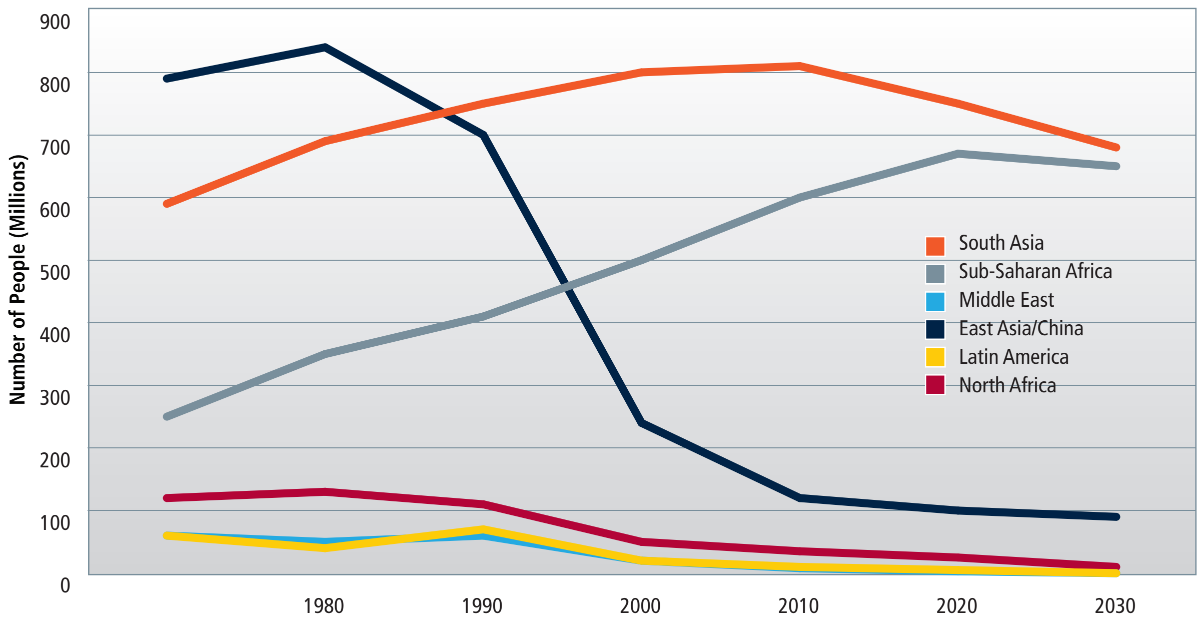
1. Community Power

1.1. Community Power Today

A report[1] on energy access published jointly by the United Nations Development Programme, UN Millennium Project and the World Bank has identified that there are clear linkages between all of the Millennium Development Goals (MDGs) and energy access. The report also argues that in order to meet the MDGs, the quality and quantity of energy services must vastly improve. The availability of energy services has clear linkages to the MDGs from both a micro and macro viewpoint. Localised examples include, lack of electricity for clinics and schools, limited lighting reducing productivity in evening hours, lack of power for income generating machinery such as irrigation pumps and the impact of using fuel wood, crop residues, and dung for cooking on health. These localised linkages aggregate to wider macro-economic benefits, demonstrated by strong correlation between commercial energy consumption and gross domestic product (GDP) in most countries.

Globally, there is a chronic lack of energy services. As per the UN report, approximately 1.6 billion people, or one-quarter of the world's population, lack access to electricity and another one billion have unreliable grid connections. A further 2.4 billion use traditional biomass fuels, such as fuel wood, for cooking. As per World Health Organisation (WHO) estimates[2], nearly 1.5 million people in developing countries, mostly women and young children, die prematurely each year from breathing the fumes from indoor biomass stoves. This indoor air pollution is also a significant cause of global warming due to black carbon emissions. The International Energy Agency (IEA) forecasts[3] 1.4 billion people will still lack electricity in 2030, as illustrated by Figure 1.

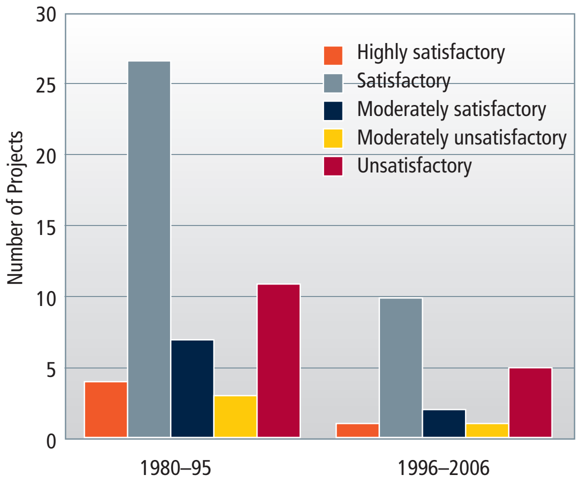
Figure 1: Number Of People (Actual And Projected) Without Electricity, 1970-2030, By Region



Source: IEA World Energy Outlook 2002

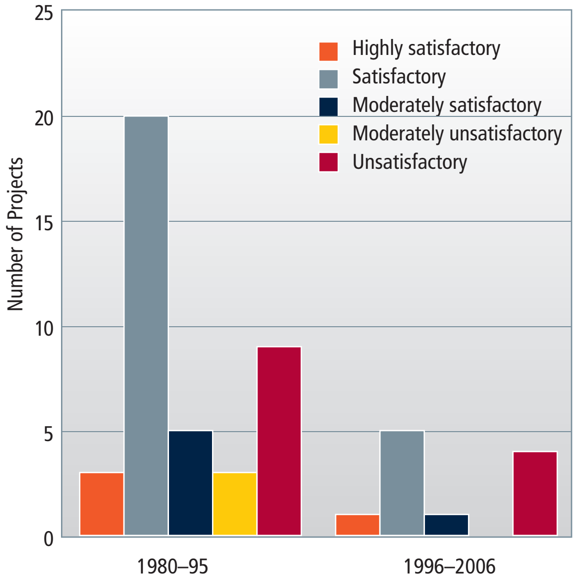
Global efforts to bring energy services to the developing world have a long and extensive history. The World Bank has implemented 120 rural electrification projects globally since 1980 with an investment of more than US$11 billion[4]. The World Bank and International Finance Corporation (IFC) are also working to bring energy services such as lighting to millions of off-grid Sub-Saharan Africans through the Lighting Africa programme. However, the success of all these rural electrification projects has been varied. The following Figures 2 and 3, which use evaluation data from the World Bank IEG Impact Evaluation report, provide an overview of the success of these projects:

Figure 2: Impact Evaluation of World Bank Rural Electrification Portfolio



Source: World Bank IEG 2008

Figure 3: Impact Evaluation of World Bank Rural Electrification Portfolio – Energy Sector Only



Source: World Bank IEG 2008

According to the report, even though World Bank-funded projects have been successful in implementing physical infrastructure for rural electrification, problems related to institutional development and technical issues still exist. The report has identified the following key barriers for successful institutional development for rural electrification, based on learning from over 25 years of investing in such projects globally:

- Lack of financial sustainability due to unclear revenue streams
- Poor operations and maintenance in some cases
- High transmission losses due to inefficient supply systems
- High connection fees and least-cost community selection criteria are barriers to reaching the very poor.

This paper will provide a viewpoint that by utilising the vast and rapidly expanding distributed energy equipment in off-grid regions of the developing world for powering telecoms infrastructure, a paradigm shift in the approach to providing energy services to developing world populations can be achieved.

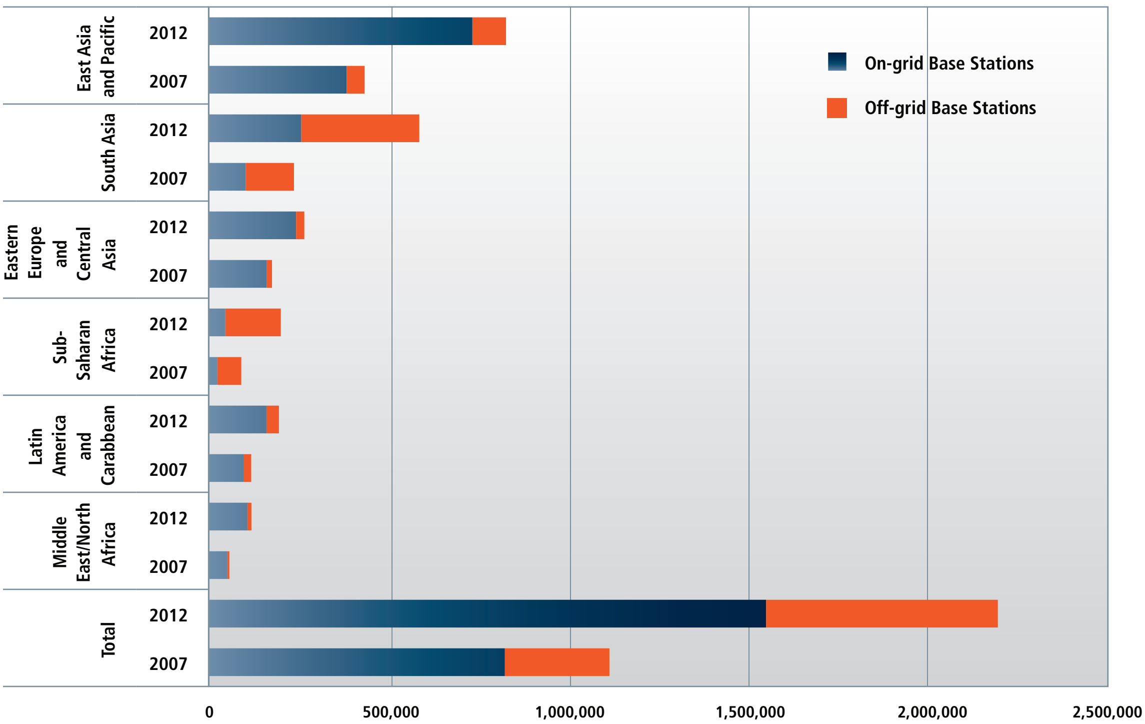
1.2. The Community Power Opportunity

The mobile phone industry has seen phenomenal growth over the past two decades. Globally, the number of mobile phone connections is now 4.5 billion and will reach 6.2 billion by 2013[5]. The majority of future growth in connections will come from developing world markets as most developed world markets are close to 100% penetration.

The geographic expansion of mobile networks to provide coverage to the global population relies on radio towers, or "base stations", that convert electricity into radio waves. In developed areas, base stations are easily connected to an electricity grid for a reliable energy supply. However, in developing areas, where grid electricity is unreliable or absent, operators have largely relied on diesel-powered generators for the supply of power to base stations. This default is now shifting, and the GSMA has established the Green Power for Mobile programme (GPM) to advance the use of renewable energy sources by the mobile industry to power 118,000 new and existing off-grid base stations in developing countries by 2012.

To provide coverage for the expanding subscriber base in developing world markets, mobile operators are deploying vast quantities of base stations. Based on available data and forecasting, the GSMA projects that the number of off-grid base stations in the developing world will increase from 288,000 in 2007 to 639,000 in 2012. These base stations are always located close to urban or rural communities as it is necessary for the subscribers to be within range of a base station's coverage.

Figure 4: Growth in Base Stations in Developing Regions 2007-2012



Source: GSMA Research

As introduced previously, off-grid base stations are either diesel powered or increasingly powered by alternative energy sources, such as solar and wind. Diesel generators are typically oversized by 5-10kW for reasons such as high network up-time requirements, bulk procurement practices and logistical issues[6]. Alternative energy systems can be slightly over-dimensioned to exceed the power requirements of the base station. This variety in base station power equipment, both in their technical capability and their ownership structures, necessitate different scenarios for implementing Community Power, which highlight two elements of this opportunity:

- The first element of this opportunity is that excess power can be used from diesel or renewable energy base stations for community energy services
- The second element of this opportunity is that the telecoms operator would provide a stable anchor demand/revenue stream for a third party Energy Service Company (ESCo) owning a larger scale alternative energy system and providing power to both the base station and the local community.

These scenarios have significant benefits for enabling provision of energy services to developing world populations since they offer ready solutions to the following key challenges for rural electrification projects:

Table 1: Key Challenges for Rural Electrification and Potential Solutions

Key Challenges for Rural Electrification[4]	Solution by Telecoms Infrastructure-based Community Power Model
Poor financial sustainability due to unclear revenue streams	Steady revenue stream from mobile operators can ensure financial sustainability
Poor operations and maintenance (O&M) of power equipment in some cases	Clear ownership of power equipment by either operator or third party energy provider and high reliability requirements of base stations ensure proper O&M by operators/third parties
High transmission losses due to inefficient supply systems	Base stations are always located near to communities reducing transmission losses
High connection fees and community selection criteria that emphasise economic returns are barriers to reaching the very poor	Telecom base stations are being installed in remote areas of the developing world, for business or universal service commitments

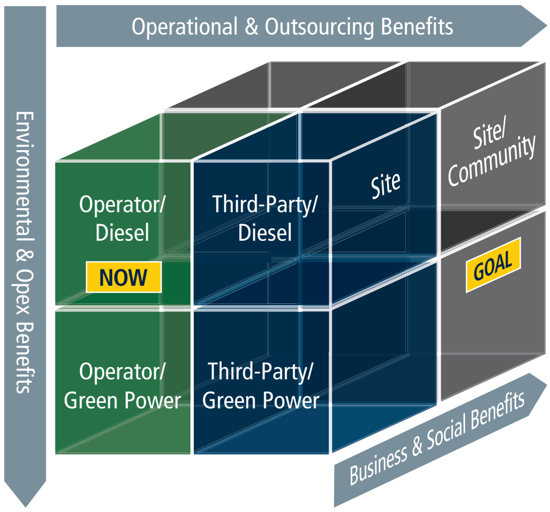
Through this report, the GSMA aims to provide a roadmap that the telecoms industry can take to move forward with this opportunity. The first chapter of this report will detail the key learnings from GSMA's research and explore the different scenarios for implementation of Community Power. Later chapters of this report will provide a deeper understanding of the third party-owned renewable ESCo scenario, through market sizing, business case modelling and financing mechanisms. The report will also detail the stakeholder landscape, policy enablers/barriers and financing requirements in Indian and East African contexts.

1.3. Community Power Scenarios

Community Power from telecom base stations can be implemented in multiple ways, depending on ownership of power equipment and power equipment type. The scenarios depicted here are ordered in increasing levels of benefits in Figure 5 below:

- A diesel generator-based scenario (left-hand top corner of the cube) can be implemented in countries where telecoms infrastructure are typically powered by diesel generators and are owned by operators themselves
- A green power-based scenario (left-hand bottom corner of the cube) can be implemented in countries where operators increasingly own several green sites
- A diesel generator-based, third party-owned scenario (right hand top corner of the cube) can be used to implement Community Power in countries where telecoms infrastructure is mainly owned by tower companies
- Finally, the scenario which has the highest potential in terms of business case and social impact is the third party-owned green power scenario which provides power to both the telecoms infrastructure and to the local communities.

Figure 5: Community Power Scenarios



Community Power Case Studies Exist

Case studies of Community Power implementations do exist in the developing world.

Safaricom, Kenya's largest mobile operator in terms of number of subscribers[5] has provided infrastructure for various Community Power applications at more than 15 of its off-grid sites in Kenya. Table 2 provides details about some of these sites.

Some of these sites are powered by diesel generators (example of scenario described in left-hand top corner of the cube) and some of them are powered by wind and solar solutions (example of the scenario described in left-hand bottom corner of the cube). A case study of Safaricom's Tegea Community Power project is provided in Appendix 1.

Grameenphone, Bangladesh's largest mobile phone operator in terms of subscribers[5] has been involved in a Community Power project in Gazipur near Dhaka, where its base station provides the anchor power load for a local rice husk-based biomass gasifer plant (example of scenario described in right-hand bottom corner of the cube). This biomass plant also provides energy to about 300 households and a few local enterprises in Gazipur. A case study of this project is provided in Appendix 1.

Table 2: Safaricom Community Power Sites

Name of the Site	Location	Community Applications Supported
Tegea	250 km North-West of Nairobi	Mobile phone charging booth Market street lighting Lighting and socket power to local community church Lighting and socket power to the site landlord and the local provincial administration (chief's house)
Faza Island	15 km South of Saadani, North Kenya Coast	Mobile phone charging booth Supply of power to local community school computer room (Personal Computers donated by Safaricom)
Chesengoch	220 km North of Nakuru	Mobile phone charging booth Lighting and socket power to mission hospital (maternity wing) Market street lighting Lighting and socket power to local community library
Archer's Post	600 km North of Nairobi	Power to local community water pumping system
Konyao	Near the Kenya-Uganda border	Mobile phone charging booth Lighting and socket power to a local community school
Kiunga Sankuri	450 km North of Mombasa on the east coast, near the Kenya-Somalia border	Mobile phone charging booth Power to local community radio
Ndau Island, Laisamis, Nyagoko, Tot, Rhamu, Sololo, Loiyangalani	Across Kenya	Mobile phone charging booths

Source: Safaricom

1.4. Key Finding 1: Operators Will Implement Simple Community Power Applications

639,000 Off-grid Base Stations Generating Power By 2012

Mobile operators already own a huge number of sites in off-grid regions of the developing world. Diesel generator-based off-grid sites are being rapidly rolled out in several parts of the world. As per GSMA estimates (see section 1.2) nearly 639,000 off-grid sites will be rolled out across the world by 2012, up from a mere 288,000 in 2007.

Green power base stations, though small in number compared to diesel base stations, are becoming increasingly common. The GSMA estimates[7] that more than 118,000 green sites will be rolled out globally by 2012. A report[8] published by IMS Research predicts 320,000 green sites will be established globally by the end of 2014 and most of these sites will be rolled out in South and South East Asia, Middle East and Africa, where grid availability is among the lowest in the world.

Business Case Exists for Handset and Large Household (12V) Battery Charging

- Implementing handset charging for off-grid communities is as simple as providing a set of power plugs at the telecom site and it is also strategic to operators - GSMA's 'Charging Choices' report[9] concludes that availability of off-grid charging options can increase mobile operator ARPUs (Average Revenue Per User) by 10-14%. GSMA research on consumer perspectives at Safaricom's Community Power sites has found that mobile phone charging is one of the three most important applications for local communities
- Implementing large household battery (12V) charging for off-grid communities is also as simple as providing a set of power plugs at the telecom site and charged batteries can be used by households to power electrical appliances in their homes. Alternatively, airtime shops can be located close to base stations, offering power plugs to charge batteries, with communities paying for this service through the same billing channel as that for airtime
- Implementing lantern charging solutions for off-grid communities is again as simple as providing a set of power plugs at the telecom site to charge lanterns powered by rechargeable batteries used in rural households. GSMA research found that most of the re-chargeable lanterns used in off-grid areas are powered by solar cells and hence, they require power plugs for charging only on days with low sunlight, and therefore demand for charging from electric power plugs is seasonal. Hence, the business case for providing lantern charging solutions is not very strong. However, mobile operators can provide this solution as part of their corporate social responsibility or branding initiatives.

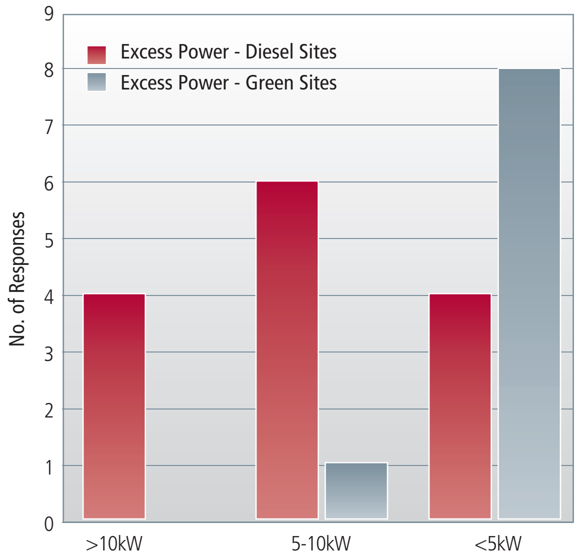
Excess Power

GSMA research based on interviews with operators, vendors and managed services companies has found that:

- Standalone (not shared) diesel sites, on an average, have about 5 kW of excess power
- High upfront investment (capital expenditure) for green power sites means that they have limited excess power availability compared to diesel sites. Nevertheless, a good business case exists for mobile operators to implement handset charging at their green power sites.

The findings of this research are as depicted by Figure 6:

Figure 6: Excess Power Availability at Diesel & Green Sites



Source: GSMA Interviews - Operator/Tower/Managed Service Companies

Business Case: Handset & Large Household (12V) Battery Charging from Diesel Sites

The business case for handset charging and large household (12V) battery charging are evaluated for both diesel generator-based and green power-based scenarios:

Diesel Sites:

Payback Period - Months (Handset Charging Only)	**8.5**
IRR (Handset Charging Only)	**140%**
Payback Period - Months (Handset & Large Household (12V) Battery Charging)	**12**
IRR (Handset & Large Household (12V) Battery Charging)	**89%**

Source: GSMA Research

Handset charging has a very strong business case with a 140% internal rate of return (IRR) and a payback period of just eight and a half months. If large household (12V) battery charging is combined with handset charging, then the business case is still strong with an 89% IRR but a slightly longer payback period of twelve months.

Green Power Sites:

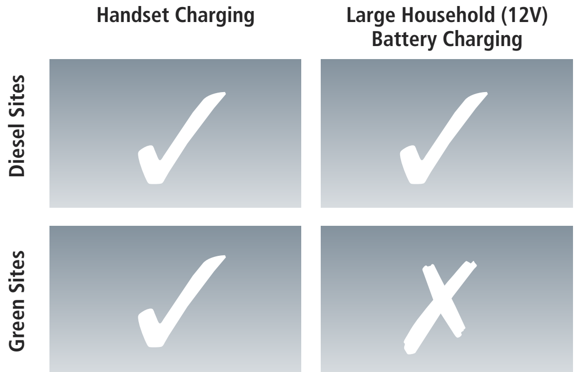
Payback Period - Months (Handset Charging Only)	**8.5**
IRR (Handset Charging Only)	**132%**
Payback Period - Months (Handset & Large Household (12V) Battery Charging)	**No Returns**
IRR (Handset & Large Household (12V) Battery Charging)	

Source: GSMA Research

Handset charging has a very strong business case even for green sites, with a 132% IRR and a payback period of just eight and a half months. However, if large household (12V) battery charging is combined with handset charging, then there is no business case (no IRR) since operational expenditure increases due to high consumption of diesel from backup generators, which in turn is due to low availability of excess power at green sites.

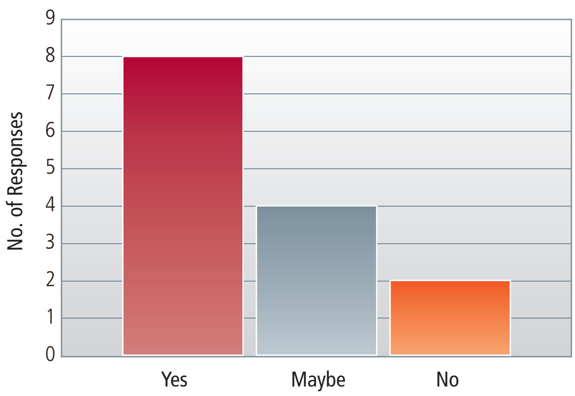
These findings are summarised in Figure 7:

Figure 7: Site Power Source Versus Community Applications



The findings from this business case analysis were confirmed by the responses to GSMA research based on interviews, which is summarised in Figure 8.

Figure 8: Handset Charging Has Strong Benefits & Low Risks

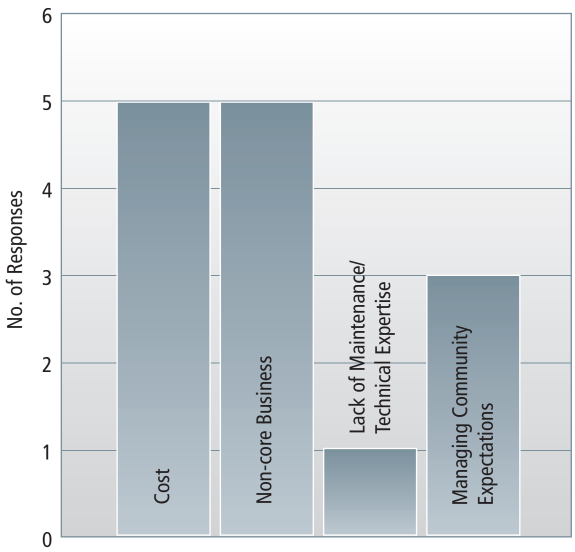


Source: GSMA Interviews - Operator/Tower/ Managed Service Companies

Barriers Exist to Operators Providing Complex Community Power Applications

Third party ESCos or Rural Electrification Organisations supplying power to telecom sites have lesser barriers than mobile operators to implement complex, high power load community applications such as electricity to households, schools and clinics. GSMA research has identified that operators are less likely to provide complex Community Power applications for the reasons identified in Figure 9.

Figure 9: Barriers for Implementing Community Power



Source: GSMA Interviews - Operator/Tower/Managed Service Companies

Cost

The cost of implementing Community Power infrastructure is an important concern for most operators/tower companies that were interviewed. This cost includes the capital expenditure (CAPEX) that might be required in some sites (without enough excess power) to over-specify the power equipment to allow for Community Power applications and also increased operational expenditure (OPEX) such as increased diesel consumption.

Non-core Business

Administrative effort involved in implementing Community Power applications is another concern for most operators and tower companies that were interviewed. This becomes a bigger concern if monitoring and billing community consumption is involved.

Lack of Maintenance/Technical Expertise

Operators and tower companies typically don't have excess capacity to maintain Community Power infrastructure. A possible solution to this would include community involvement. However, it is a difficult model to scale, particularly in markets with low levels of education and skills.

Managing Community Expectations

Once a community is provided electricity, expectations rise and they expect reliable service. Also, they might demand more services once basic service is provided. Managing these expectations is a concern for most operators and tower companies.

As described by a leading pan-African mobile operator, "Providing Community Power may turn into high expectation that the community will always get power and this becomes an issue if we don't have excess power".

It is also very important that the Community Power applications implemented match the energy needs of the local community. GSMA research on consumer perspectives at Community Power sites found that in some cases, the local community was not consulted before the implementation and that has resulted in low utility of Community Power infrastructure.

1.5. Key Finding 2: Third Parties Will Implement Complex Community Power Applications

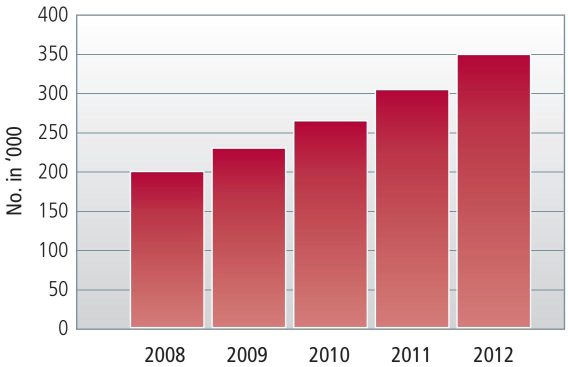
Mobile Operators Have Already Adopted an Outsourced/Managed Services Business Model

Increased market competition in high growth markets such as India has put tremendous pressure on the operating margins of mobile operators, which is driving increased popularity of the outsourced/managed services business model.

Operators already outsource several of their critical but non-core functions – from call centres to network infrastructure, which enable them to reduce their operating costs. This is especially attractive in emerging markets where ARPUs are typically very low. For example, India's largest mobile operator, in terms of subscribers, Bharti Airtel[5], has successfully adopted the managed services model which allows it to focus on enhancing customer experience and product innovation[10].

The best illustration of this model is the telecom tower infrastructure industry in India, whose structure has undergone a significant change in the last two years due to the arrival of tower companies who now own more than 80% of the country's telecom towers[11]. Tower companies build and lease telecom towers for operators to setup their base stations. The growth in the Indian telecom tower industry is illustrated in Figure 10.

Figure 10: Growth Projections of Tower Company-owned Sites in India

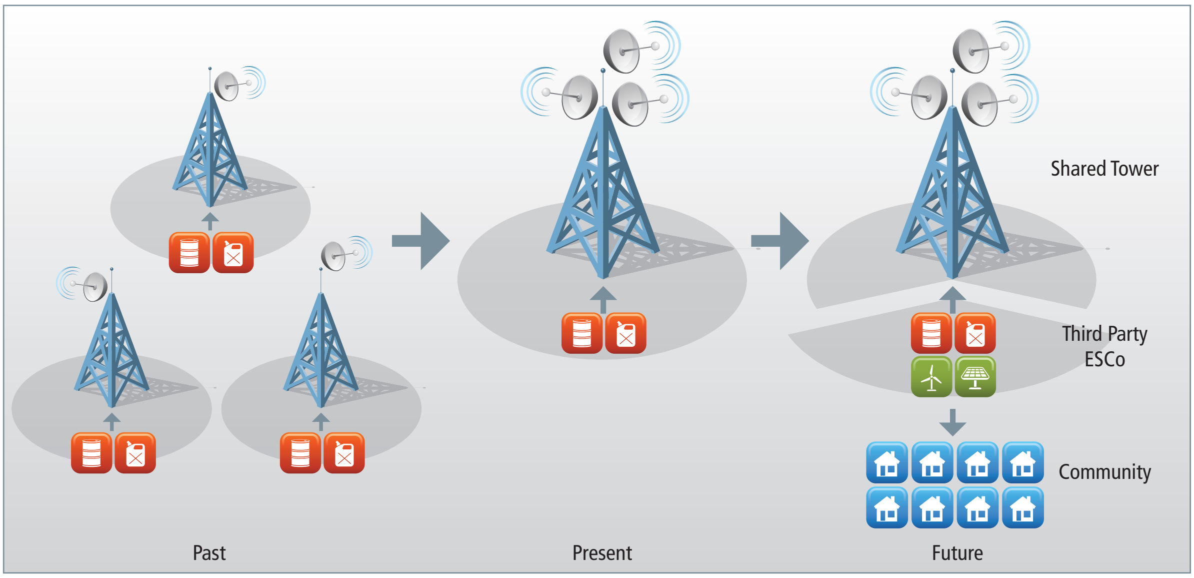


Source: Standard Chartered Market Analysis Report September 2009

- According to a report[12], there are an estimated 240,000 towers in India today, and this number is expected to grow to more than 350,000 by 2012
- These sites are designed to be shared and hence have less excess power
- Similar high growth markets such as Nigeria and Indonesia are quickly adopting this model.

The evolution of managed services/outsourcing model is described in Figure 11:

Figure 11: Evolution of Telecoms Infrastructure Business Models



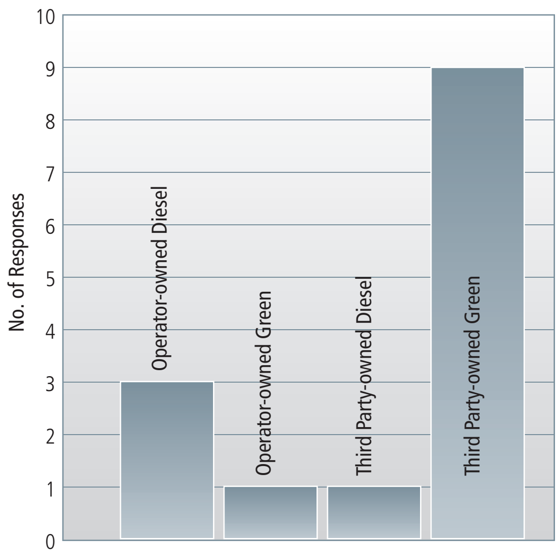
Thus, most mobile operators and tower companies do not see a risk in outsourcing their power requirements to managed services or third party ESCos.

Operators Favour The Third Party Community Power Scenario

Mobile operators and tower companies have strong interest in the scenario whereby third party-owned green power plants provide power to local communities and telecom towers. However, these third parties need to provide very high quality service with minimum outages since operators/tower companies have very high service level requirements.

GSMA research on the preferred scenario for Community Power implementation has found that, several operators and tower companies are willing to pilot this scenario. Figure 12 summarises this research.

Figure 12: Preferred Community Power Scenario

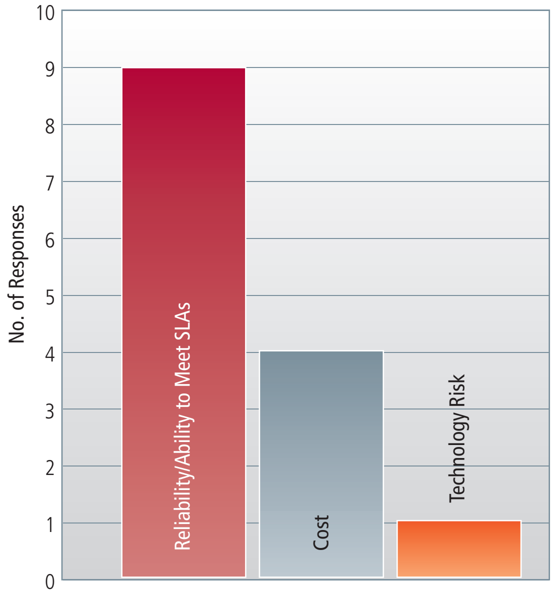


Source: GSMA Interviews - Operator/Tower/Managed Service Companies

As described by a leading Indian tower company, "The energy supply company must provide 24/7 energy supply. They can't run for a year or two and then stop. We need a long term contract with them. However, NGOs in India are very efficient in providing such energy supply. We are already working with a Community Power plant on this model".

A global mobile operator said, "We would welcome more Community Power companies. But we would need them to be professional companies. Our expectations are high. These companies have to compete with diesel generators which provide the lowest-risk option". Figure 13 summarises this research.

Figure 13: Concerns for Outsourcing Power to a Third Party ESCo



Source: GSMA Interviews - Operator/Tower/Managed Service Companies

Conclusion

- An opportunity exists to create a new business model for off-grid energy access by combining power demand from mobile base stations and communities, thus creating strong business and social value
- Operator-owned sites will implement simple Community Power applications such as handset charging and large household (12V) battery charging
- Mobile operators and tower companies already outsource several of their core functions and are willing to adopt the third party green power scenario, if their high service level requirements can be met.

2.The Implementation of Community Power

The rest of the paper analyses the third party green ESCo model which is the most ambitious of all of the market scenarios defined in Chapter 1.

Premise:

- There is a latent demand for medium-scale rural electrification and new base stations (BTSs) in off-grid locations
- Renewable energy can be used to provide 10 – 50kW peak load, making biomass and to some extent wind, the most appropriate renewable technologies. Currently, solar carries greater uncertainty due to high investment costs and land requirements at such loads
- Third party ESCos own/operate these renewable energy plants located close to both rural communities and the base stations
- Mobile operators provide anchor demand for power and a stable revenue stream
- Provision of power to local communities drives additional revenue for the third party ESCo
- Development finance and/or carbon finance may be incorporated to improve business case
- Regulatory environment allows - or is forecast to allow in the short-term - for distributed power generation and distribution with favourable terms.

This chapter aims to highlight how such a market scenario can be developed in a number of emerging markets in which the deployment of rural electrification and increased telecommunication infrastructure are in demand by the government and local communities.

Initially, it lays out the range of different renewable technologies appropriate for Community Power and assesses the global market opportunity.

A generic business case is provided, which details the economics of different solutions based on varying supply constraints and demand requirements.

In Chapters 3 and 4, the opportunity to implement this scenario is illustrated by studying two regions in detail. India and East Africa were chosen, with the objective of providing for each market:

- Context on state of market: development needs in the market, state of rural electrification, state of telecoms infrastructure development, regulatory regime
- Specific policy barriers and enablers in market
- Financing and external support available to market
- Case study of an existing rural electrification programme in market
- Value proposition for Community Power

2.1. Technology Choices

A wide array of green power technologies have been assessed for Community Power. An overview of this analysis is shown in Table 3.

Table 3 - Technology Choices

	Diesel (BTS Only, No Community Power)	Wind with Diesel Backup	Biomass Gasification (Vegetation) with Diesel Backup	Biodigester (Manure)	Pico Hydro with Diesel Backup	Solar PV with Diesel Backup
Power Output	5kW – >100kW	<1kW - >100kW	3kW – >100kW	1kW – >100kW	<1kW - 100kW	Scalable
Asset Lifetime	3 years	20 years	10-15 years	20-30 years	25-30 years	20-25 years
Maturity	Very mature – widely used	Established	Mature	Mature	Lacks commercial maturity	Price points declining rapidly
Requirements	Diesel supply chain	Wind speeds 5m/s for >50% of year	Large volumes of vegetation feedstock ≈ 50 hectares worth of crops	High concentration of collectable manure e.g. a dairy with 500 cows	Stream with a head of 60m and flow of 100l/s year round	Insolation >5kWh/m^2/day
Reliability of Energy Source	High, but dependant on distribution partners	Wind speed is unreliable	Subject to harvest	Dependent on local buy-in and incentivisation	Consistent and predictable	Some variation, depending on location
Advantages	Tried and tested technology Skills available for maintenance	Relatively cheap, low maintenance	Can use products that would otherwise be wasted, generator also runs on diesel	Manure is cheap and locally sourced, generator also runs on diesel	Small OPEX, constant supply of power, low maintenance	Very little maintenance
Disadvantages	High carbon footprint, fuel is expensive and volatile, needs regular maintenance	Variability in wind speed is hard to gauge	Supply chain of fuel may break down if farmers have more lucrative land uses, fuel crops could compete with food crops	Fuel supply may run out, dependent on local supply chain	Very few suitable sites	Expensive at scale, risk of theft

Source: GSMA Research

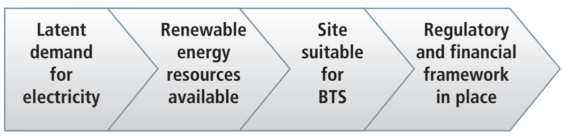
Biomass gasification technology is presently evaluated as the most suitable technology to utilise for Community Power due to the maturity, wide applicability and attractive energy price. Wind solutions can also be attractive with external financial support.

2.2. Market Sizing

In this section, the opportunity to implement Community Power is studied at a high-level, with the objective of assessing the total market opportunity for implementing Community Power. This analysis is used to prioritise countries or regions for a more in-depth investigation.

Methodology

The key conditions that need to be in place in order for Community Power to be viable are summarised below:



Each of these attributes will be considered in turn. The regulatory and financial environment is specific to each country. Therefore, this will only be considered on a case by case basis once the countries with the most potential for Community Power have been identified.

Global data has been gathered on each of the other initial three conditions. The study takes average values for each data set over an area of one degree of longitude by one degree of latitude for each of the countries considered by Community Power.

Latent Demand for Electricity

Community Power targets areas where grid electricity is not available. The location of communities connected to the grid can be approximated by using NASA's Earth's City Lights map, as shown in Figure 14

Figure 14: Earth's City Lights Used to Assess Grid Availability

Source: NASA Earth Observatory Website

For greater accuracy, the NASA data has been combined with UN data[13] that gives known electrification rates for all countries.

This provides, at a global level, an indicative probability of a particular geographical location having electricity. The opportunity for Community Power, based only on this first filter, is shown in Figure 15.

Figure 15: Opportunity for Community Power Based On Lack of Available Grid

Source: GSMA Research

Availability of Renewable Energy Resources

The second filter narrows down the choice of locations to those areas where there is a sufficient source of renewable energy. Wind and biomass have been chosen as the two most appropriate green power technologies for Community Power, due to considerations of:

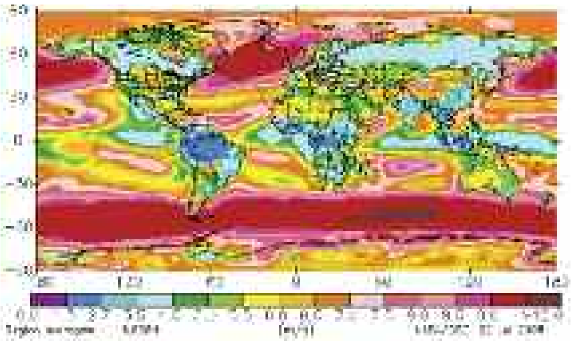
- Maturity of technology
- Low upfront costs
- Broad applicability across a wide range of sites.

If the recent downward trend in the price of photovoltaic solar modules continues, this technology may become more suitable for Community Power projects in the near future.

The strength and consistency of wind and the availability of biomass have been assessed for each location.

Figure 16 shows the average annual wind speeds across the globe. Combining this data with information from NASA[14] on the reliability of those wind speeds allows an estimation of the suitability of each site for wind powered Community Power.

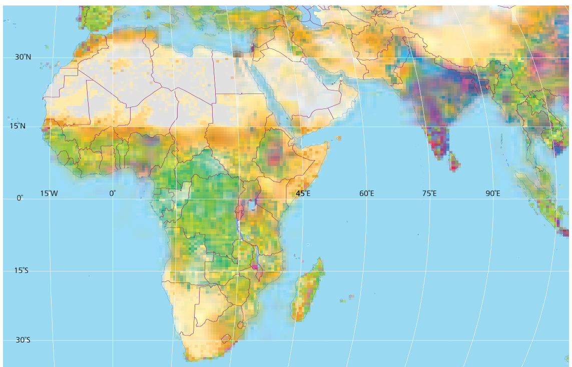
Figure 16: Global Wind Speeds



Source: Atmospheric Science Data Centre, NASA

The viability of using biomass to generate energy heavily depends on the specific site conditions. However, for this high level analysis, sites that are unlikely to have sufficient biomass are ruled out for Community Power. The suitability of land for producing biomass can be gauged from biomes data. Figure 17 shows a pictorial representation of the NASA biomes data for Africa and South Asia. It is assumed that areas designated as forests, croplands, and villages would be most suitable for power generation from biomass.

Figure 17: Available Biomass in Africa and South Asia



- Wildlands
- Forests
- Rangelands
- Croplands
- Villages
- Urban

Source: National Council of Science and the Environment, 2008

Areas which have either sufficient wind resources or biomass resources (or both) could be suitable for Community Power. These locations are shown in Figure 18.

Figure 18: Locations with Suitable Renewable Resource Availability

- Suitable for Wind
- Suitable for Biomass
- Suitable for Wind or Biomass
- Not Suitable
- Country Not Analysed

Source: GSMA Research

Site Suitability for Base Station

This filter considers whether a Community Power BTS could be built or upgraded in a particular area:

- Areas currently without mobile coverage could be suitable for expansion of GSM coverage if the population density is high enough
- Areas already covered by a mobile network could be suitable for an "upgrade" where the existing BTS is powered by diesel.

Areas where the population density is high enough to potentially make the BTS economically viable are shown in Figure 19:

Figure 19: Areas with Population Density High Enough for GSM

- Suitable for GSM Base Station
- Not Suitable
- Country Not Analysed

Source: GSMA Research

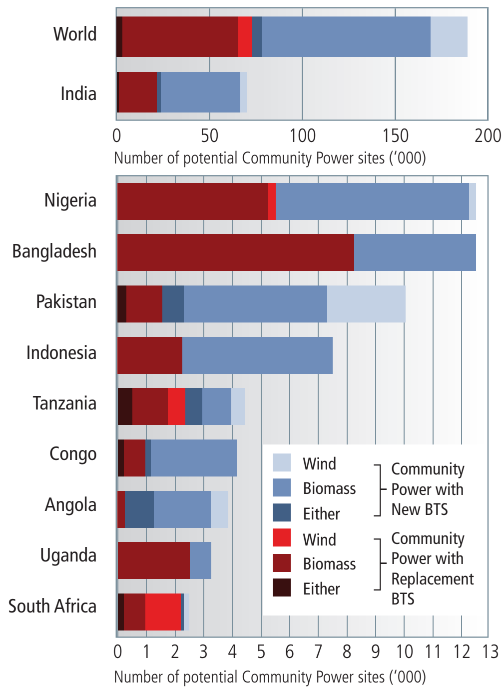
Potential for Community Power

The market sizing analysis has been carried out using global data at a resolution of one degree of latitude by one degree of longitude. This indicates which areas of the world would to be feasible and the number of Community Power BTS that could be built or upgraded in each of these areas is then estimated as shown in the map (Figure 20) and chart (Figure 21) below.

Figure 20: Locations with Opportunity for Community Power

Source: GSMA Research

Figure 21: Community Power Potential by Country



Source: GSMA Research

The analysis indicates that there is a potential for nearly 200,000 Community Power sites worldwide. If each site that appears suitable for Community Power is developed to provide power to a local community of 150 houses, then this could impact nearly 100 million people in the top ten countries alone and a total of 120 million people from all countries with Community Power potential.

Of the markets earmarked in this analysis, India, and East Africa (comprising Tanzania, Uganda, and Kenya) are analysed in more details in the next section, due to a combination of significant latent demand for electricity and telecoms infrastructure, sufficient power generation capacity and existing interest from stakeholders and investors.

2.2. Business Case for the Community Power Solution

Overview

This section describes and quantifies an illustrative business case for Community Power. The purpose of this section is to lay out the key drivers, and indicate the conditions required in order to make such an initiative financially viable. All of the input parameters (costs, power, wind conditions etc) are taken from existing initiatives or from primary data, but in practice will vary considerably from site to site.

Scenarios are provided so that the economic impact can be assessed for these different parameters. The price of electricity has been modelled so as to make the entire project profitable, and this price has been tested against what communities are willing to pay for electricity, and against what telecoms companies currently pay for off-grid electricity. Subsidies and grants will allow the pricing to be reduced.

The business case assumes an energy supply delivering a peak load of 27kW to power a BTS site and a community. Examples are quantified for both a wind and a biomass solution.

- **Electricity Supply:**
  Community Power is targeting areas without any grid electricity. Although renewable energy could supplement local grid electricity in regions where it is unreliable, the technical and regulatory difficulties of connecting the renewable energy source into the existing distribution infrastructure, and dedicating it for use by the community rather than selling it back to the grid, makes this option less attractive. Building a duplicate micro-grid would not be cost effective. Moreover, the average price of grid electricity in the developing world is around US$0.01 to US$0.10 per kWh, which is an order of magnitude cheaper than energy from diesel generators or small scale green power technologies. Where there is grid nearby, extending the grid would be a more suitable option. Therefore areas where there is an unreliable grid are not being considered in this analysis.

- **Electricity Demand:**
  Securing reliable and long term buyers of electricity is a critical premise behind Community Power. While the BTS will be the anchor tenant, having an established enterprise in the community to enter in to an off-take contract is a critical element of the value proposition. Historically, many Community Power projects have failed as the electricity demand from individual households has not materialised as planned. As long as there is a sufficient base of electricity demand, the overall economic and social benefits will improve as individuals in the community gradually find uses for the electricity.

- **Base Station:**
  The BTS site will be the key anchor tenant and integral to the initiative. Power requirements of BTSs have been reducing significantly over the last few years due to improved technology and reduced cooling requirements, and can often require as little as 1kW. A 2kW power requirement for standalone outdoor BTSs and 5kW power requirement for shared BTSs have been assumed. Sites that require air conditioning (indoor BTSs) will require more power.

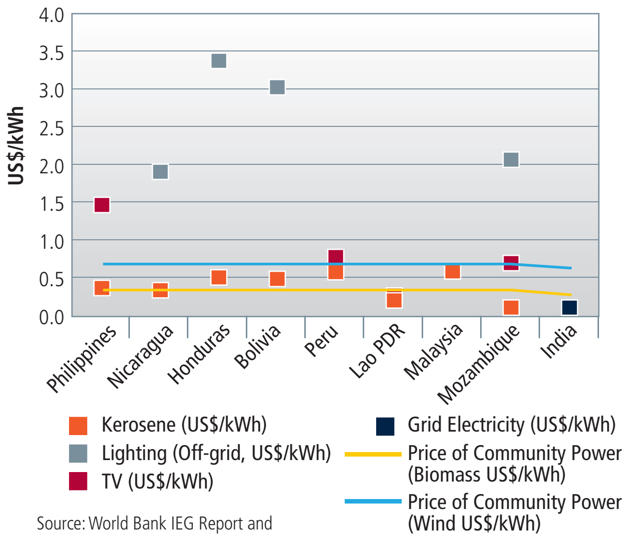
  The business cases cover the situation where a new BTS is being built. The opportunity is equally applicable to replacing existing diesel generators with a renewable energy solution and supplying the community with the excess power. The financial payback period for the replacement case will be slightly longer than for the new build case, but the overall development risks will be slightly lower.

- **Electricity Price:**
  A diesel generator running at full load typically supplies electricity at around US$0.10/kWh to US$0.20/kWh. However, if the generator is not operating at full load, the costs may reach US$1.20/kWh at 20% load. The cost of supplying energy from green power technologies should lie between these values to be viable without major subsidies. Kerosene costs between US$0.3 and US$0.6/kWh, and a recent report from the World Bank[4] suggests that the price rural communities

are willing to pay for electricity is within these ranges, and much higher for lighting in off-grid areas.

Nevertheless, even though the willingness to pay estimated in the World Bank report is very high in most developing countries, several rural electrification organisations, which were interviewed by GSMA, have found that US$0.20-US$0.30/kWh is the price range that the communities can actually pay for electricity.

Figure 22: Willingness to Pay for Energy



Source: World Bank IEG Report and GSMA Research

Population Density:
An area with high population density will be more attractive, as the likely demand for mobile and electricity will be greater. Population density is not critical for micro-grid development if the main anchor tenants are to be a BTS and an enterprise. However, the social benefits will clearly be greater if more individuals benefit.

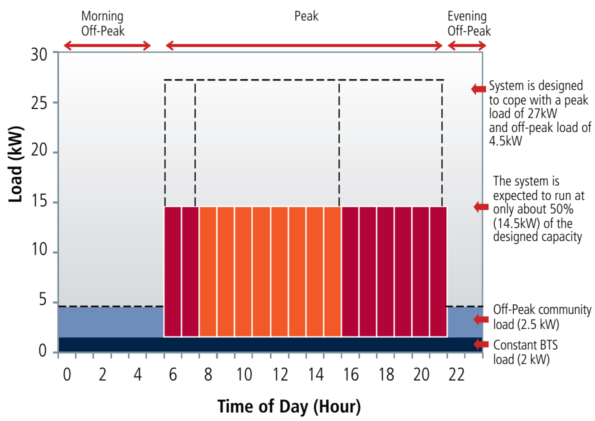
Micro-grid:
A meaningful proportion of the cost of a Community Power project is the local electricity grid required to distribute the power to the community. Ideally, having a network of less than a kilometre will negate the requirements for electrical transformers and reduce the distribution costs. Thus, the base case assumes 1 km of low voltage transmission lines and no electrical transformers.

Assumptions Behind the Business Cases

The power generation systems in the following business cases have been designed to meet the following criteria:

- Support a BTS consuming 48kWh/day.
  The BTS is assumed to be an outdoor single operator site, drawing a constant power of 2kW throughout the day
- The system is designed to support a community energy demand of up to a maximum of 440kWh/day. However, to allow for realistic scaling up of electricity demand from the community, the price of the electricity is set such that the payback will be seven years at 220kWh/day
- This peak power usage is consistent with supplying 150 houses with 170W of power to use during the early morning and evening. This is sufficient to power a few lights in each household, charge mobile phones, plus power appliances such as fans. Given the households use this energy over a period of eight hours each day, this equates to a monthly consumption of 40kWh/month per household – a number consistent with current research[4]. See Figure 23 for a diagram of the load profile for the community
- During the middle of the day, the energy will be used to power local enterprises, such as mills, water pumps, shops, and entertainment centres. Outside of the period of peak demand, electricity will still be available to power refrigerators, street lights, and other constant demand applications.

Figure 23: Load Profile of Community and BTS



Source: GSMA Research

- Batteries act as a backup and supply electricity to the BTS and community while the primary energy sources are off or inactive
- The project lifetime is assumed to be fifteen years, while a discount rate of 15% is used to calculate present values.

General Risks

Supply Side Risks

- Almost all sources of energy have some risk inherent in the supply of the fuel, whether that be diesel, wind, sunlight, water or biomass.

Demand Side Risk

- It may take some time before the demand for electricity from the community reaches the level that the system is designed to supply. During this time, the cost of energy will be higher than planned
- This risk can be partially mitigated by setting the electricity price such that the system breaks even at low loads over the required payback period
- Should demand exceed the planned supply of electricity, the generator can be turned on for longer and the bank of batteries increased.

Maintenance Risk

- Skills for maintaining the equipment need to be in place before the project commences, or introduced during a pilot phase
- Incentives should be designed to ensure that the skills, once developed within a community, remain in the community for the project duration.

Societal Risk

- Ownership of Community Power site, both the land and the equipment, needs to be clear and contractually robust
- Community involvement in the project from the outset will help reduce the risk of theft or sabotage.

Business Case for a Biomass Gasifier-based Community Power Solution

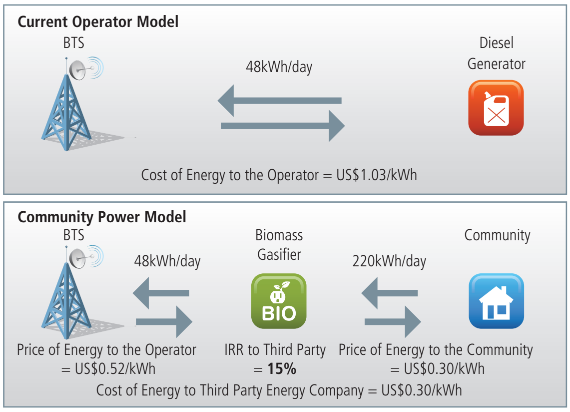
This example is based on a biomass gasifier providing power to a BTS and the local community. It is a case study that has been developed by analysing data from several different sources and projects. The main assumptions:

- 50kVA (40 kW) generator powered with gasified dhaincha plants[15]
- The generator is located in the community, while the BTS is within 1 km range of the community.

This system has the following characteristics:

- The average price of energy (to community and BTS) required to give a seven year payback is US$0.34/kWh, which gives an IRR of 15%
- Revenues that can be generated by the plant through selling of dry charcoal produced from the biomass gasification process are also considered
- In the future, waste heat can be used to drive cooling systems for air-conditioners of the BTS
- Potential revenues from carbon credits are not considered due to uncertainties in the longevity of global carbon agreements and also to make the business case generic to all markets
- A differential pricing model is used, with the telecom tower expected to pay a premium price of US$0.52/kWh and communities/rural enterprises/households expected to pay a lower price at US$0.30/kWh. Even though the price that communities pay here is lower than their willingness to pay estimated in the World Bank report, research based on interviews with rural electrification organisations has revealed that US$0.20-US$0.30/kWh is the price that the communities can pay for electricity. Also, at US$0.52/kWh, telecom towers in most countries will still be spending less than what they are currently spending on power at their off-grid sites.

Figure 24: Comparison of Biomass Community Power with Diesel-based BTS Power



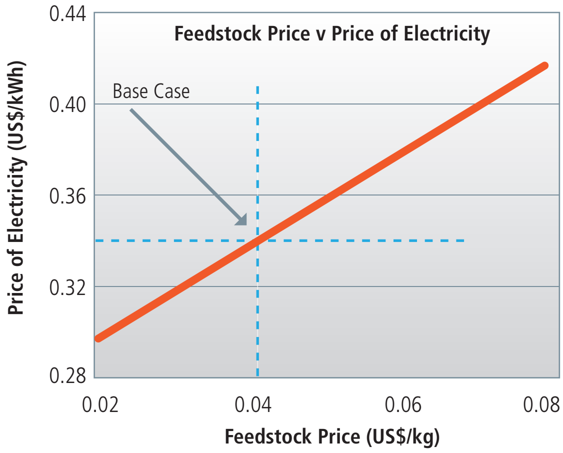
Source: GSMA Research

Sensitivities and Risks

- The sustained availability of feedstock is one of the biggest risks to any biomass project
  - The feedstock should be chosen such that it does not compete for land with other crops
  - Seasonal variations in feedstock supply need to be factored in
  - The gasifier can accept a wide range of feedstock, so the supply is not dependent upon a single source
  - Using a dual fuel generator means that it can run on pure diesel, reducing the impact of feedstock shortages

The following charts outline a series of scenarios by identifying key sensitivities. The electricity price is calculated so as to provide a seven year payback on the costs of building and running the generation equipment and the micro grid, and is therefore directly related to the cost of generating and distributing the electricity.

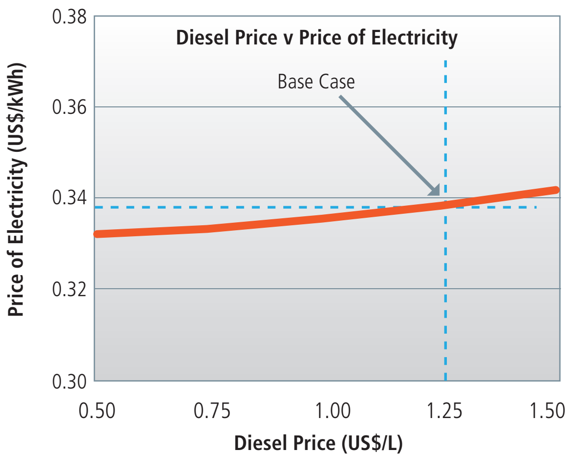
Figure 25: Sensitivity of Price of Electricity to Feedstock Price Variations



Source: GSMA Research

Feedstock prices can be highly volatile. Agreeing long term volume and price contracts will give certainty to both the Community Power operators and to the farmers, however an above market price may be required to guarantee supply.

Figure 26: Sensitivity of Price of Electricity to Diesel

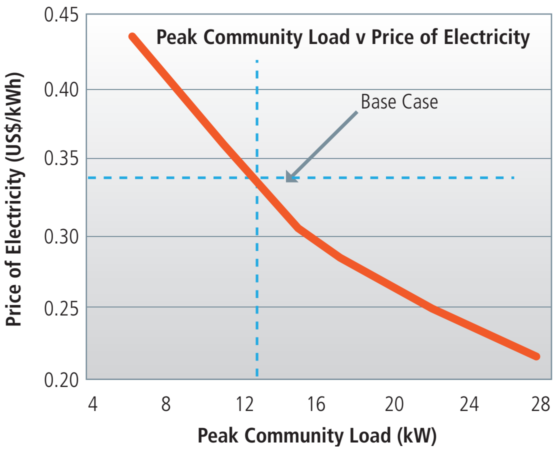


Source: GSMA Research

Price Variations

Diesel is usually only used for 2% of the time, so has a limited impact on the overall economics. If the supply of biomass is compromised, the impact will be greater.

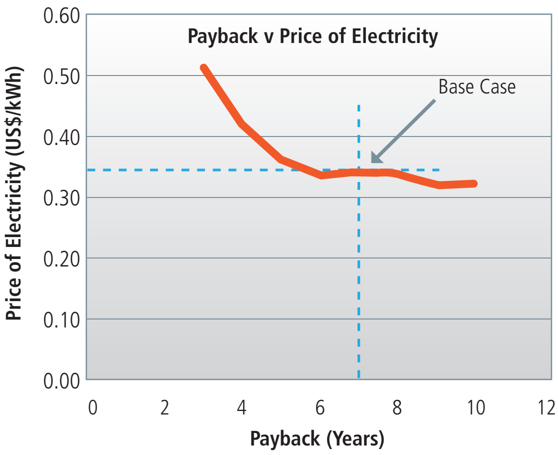
Figure 27: Sensitivity of Price of Electricity to Peak Community Load Variations



Source: GSMA Research

This system has been designed for a peak community load of 25kW. If less power is drawn from the system, then the cost of energy will increase as the same capital expenditure will be spread out over fewer kilowatt-hours during the lifetime of the project. The base case assumes a peak community load of 12.5kW.

Figure 28: Sensitivity of Price of Electricity to Payback Period Variations



Source: GSMA Research

The electricity price has been set such that there is a financial payback within seven years for a given load requirement. In practice, electricity demand will be highly price elastic.

Business Case for a Biomass Gasifier-based Community Power Solution in India

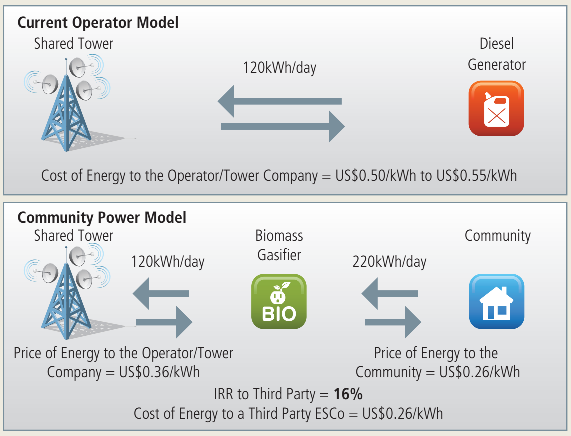
The business case for Community Power in India is based on gasified biomass, burnt in a dual fuel generator. The business case here differs from the generic business case in the following ways:

- The prevalence of operators sharing infrastructure means that the BTS site loads have been increased from 2kW to 5 kW. Hence, the system in the India business case model can handle peak power loads of 30 kW (25 kW community load and 5 kW BTS load). The system is expected to typically handle about 17.5 kW load (community load at 50% of peak).
- Diesel cost of US$1.00 per litre, rather than US$1.25.

A system of this type has the following characteristics over the project lifetime of fifteen years, if the average daily consumption of energy from the community (including enterprises) is 220kWh/day, giving a load factor of just over 50%:

- The average cost of energy is US$0.26/kWh
- The average price of energy (to community and BTS) required to give a 7-year payback is US$0.29/kWh, which gives an IRR of 16%
- The price charged to telecom towers of US$0.36/kWh is considerably lower than cost per unit of electricity that tower companies in India are currently incurring, which is in the range of US$0.50 to US$0.55/kWh
- The price charged to the community is US$0.26/kWh in line with the willingness to pay estimates
- Available subsidies from the Indian government have not been considered in building this model. If these subsidies are also considered, then the business case will be more attractive.

Figure 29: Comparison of Biomass Community Power with Diesel-based BTS Power in India



Source: GSMA Research

Business Case for a Wind-based Community Power Solution

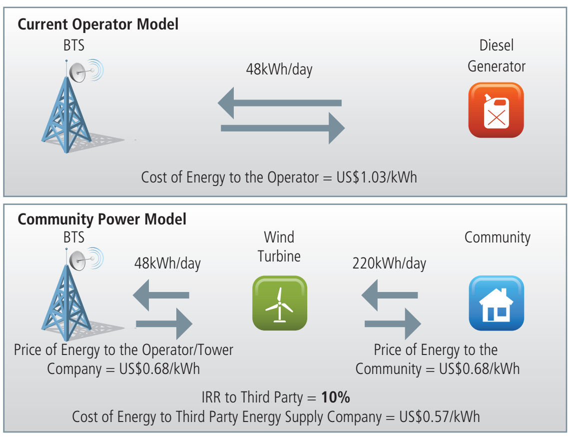
The second business case for Community Power considers a similar system to the biomass gasifier case, but in this instance, a wind turbine provides the green power. The main assumptions are:

- Wind turbine with a 30kW peak power output
- 40kVA (30 kW) backup generator, to provide power when the wind speed is not sufficient to power the system
- Batteries to store excess energy from the wind turbine to use in times of low wind speeds and also to reduce the run time of the backup generator.

This system has the following characteristics:

- The internal rate of return is 10%
- The high cost and price of electricity (US$0.57 and US$0.68 per kWh respectively) make it difficult to use a differential pricing model in a wind-based solution, since pushing down the price of electricity for communities to US$0.30/kWh will result in very high prices for telecom towers (higher than what they currently pay at diesel generator based sites) and hence, wind-based business model seems unviable without external financial support.

Figure 30: Comparison of Wind Community Power with Diesel-based BTS Power

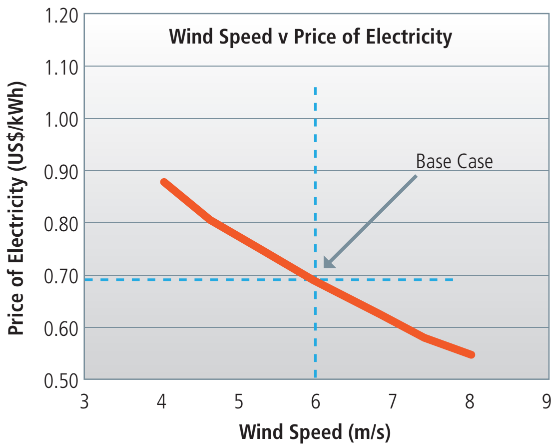


Source: GSMA Research

Sensitivities and Risks

The following charts outline a series of scenarios by identifying key sensitivities.

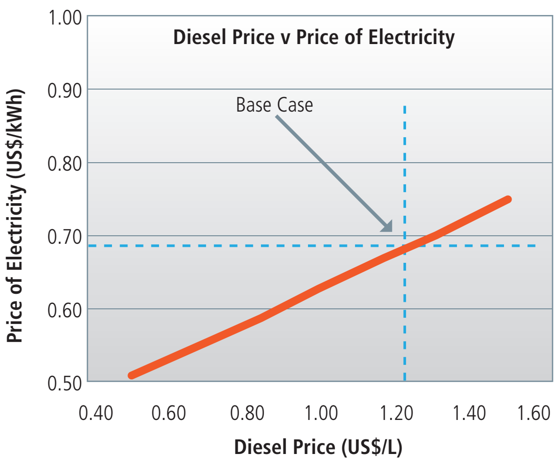
Figure 31: Sensitivity of Price of Electricity to Average Wind Speed Variations



Source: GSMA Research

The wind speed has a strong impact on the cost of energy. The lower availability of wind resources forces the backup generator to switch on more frequently, raising the amount spent on fuel.

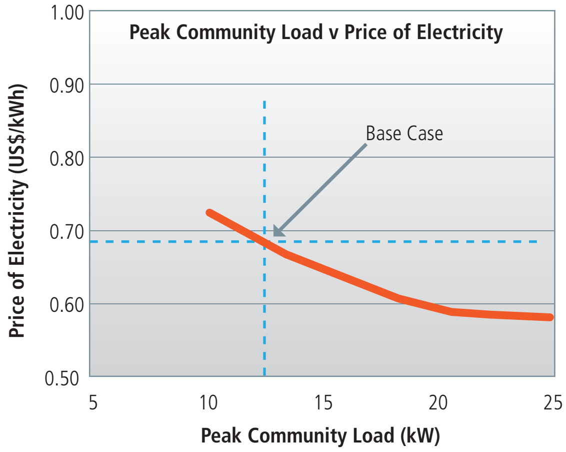
Figure 32: Sensitivity of Price of Electricity to Diesel Price Variations



Source: GSMA Research

At 27kW loads, the back-up diesel generator will account for a significant proportion of the power output. Hence the price of diesel will have a material effect on the overall economics.

Figure 33: Sensitivity of Price of Electricity to Peak Community Load Variations



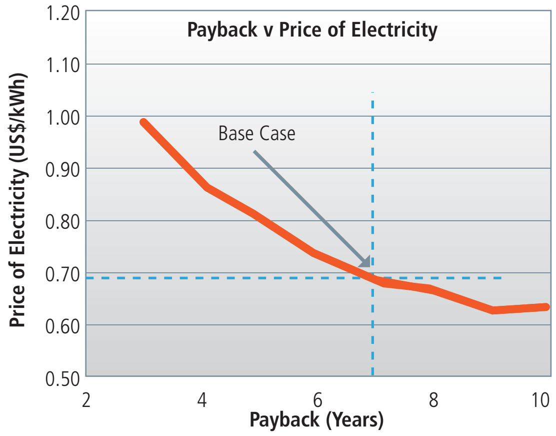
Source: GSMA Research

This system has been designed for a peak load of 27kW. If less power is drawn from the system, then the cost of energy will increase as the same capital expenditure will be spread out over fewer purchased kilowatt-hours during the lifetime of the project. The base case assumes a 12.5kW community load.

Risk for Wind Power

The 30kW wind turbine used in this example weighs 1.5 tonnes and the tower on which it is placed needs to be greater than 30m high. Therefore the logistics of constructing the turbine, especially if in a hard-to-reach location, will be difficult and may add significantly to the installation cost. In some areas it may be more cost effective to use a series of smaller wind turbines instead of a single large one. This solution may have lower installation costs, and be easier to maintain than large systems. However, the equipment cost per kilowatt of peak output will be higher with small turbines.

Figure 34: Sensitivity of Price of Electricity to Payback Period Variations



Source: GSMA Research

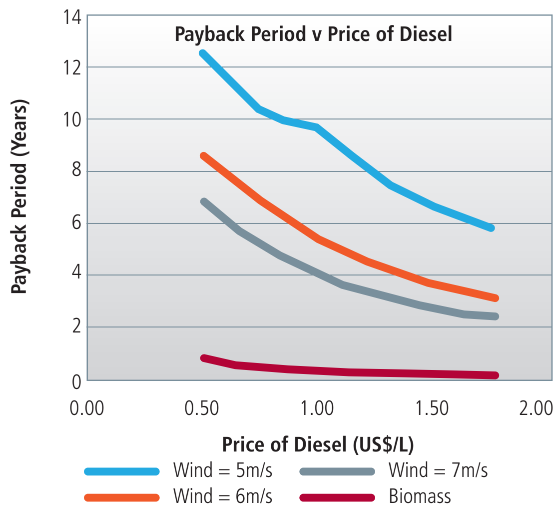
The electricity price is calculated so as to provide a seven year payback on the costs of building and running the generation equipment and the micro grid, and is therefore directly related to the cost of generating and distributing the electricity. The electricity price has been set such that there is a financial payback within seven years for a given load requirement. In practice, electricity demand will be highly price elastic.

Impact of Diesel Price on Payback Period of Community Power Solutions

Figure 35 shows the payback period of renewable energy-based solutions providing power to a 27 kW community and BTS peak load, as described in the generic business case in the previous section, versus providing power to the same 27kW peak load using a diesel only solution. It has to be noted that the payback periods calculated for wind and biomass solutions here are relative to the costs associated with a diesel-only Community Power solution and hence are different from the payback periods described in the previous section where absolute payback periods were calculated.

If local supply chain issues can be overcome, then biomass is an exceptionally cost-effective way of providing electricity to the community when compared to diesel-only solutions, with payback periods below one year. For wind solutions, average wind speed and diesel price have significant impact on the business case, and payback periods are between ~2.5 years and ~12.5 years dependant on these factors.

Figure 35: Payback of Wind and Biomass Community Power Solutions Against a Diesel-only Solution



Source: GSMA Research

Business Case Summary

To summarise the business case analysis:

- The business case models are designed to handle up to 27 kW peak load generally (up to 30 kW in India where BTS loads are higher due to site sharing market structure)
- The biomass gasification-based business model offers the best possible price of electricity, both in the general case and Indian case, even without considering government subsidies and carbon revenues. Even if a premium is charged to telecom towers to keep the price charged to communities lower than US$0.30, it will be lower than the cost incurred by off-grid diesel generator-based telecom towers currently
- Nevertheless, the price of electricity in the biomass business models is sensitive to variations in factors such as feedstock price, diesel price, community load and expected payback period
- The wind-based business case does not provide an attractive price of electricity both to telecom towers and communities. Government subsidies might make this business case attractive
- The price of electricity in the wind business models is sensitive to variations in factors such as average wind speed, diesel price, community load and expected payback period.

2.3. Considerations on Financing and External Support Requirements and Sourcing

Access to electricity has marked welfare improvements[16], particularly for health and education provision and micro-enterprise development.

Successful and sustained off-grid electrification projects commonly utilise a combination of international co-financing and external technical knowledge. Sources include investment funds, foundations, private companies, multilateral aid assistance and the Clean Development Mechanism (CDM).

Practical knowledge and international experience accumulated by the GSMA via past and ongoing projects reveals that successful projects advocate the current development paradigm of coupling innovative market-based approaches with philanthropic capital, subsides, and grants.

Context

According to the World Bank, there are 260 million rural households in the developing world without access to electricity[17]. A significant portion of this population resides in small or dispersed communities un-served by and/or far from national grid infrastructure.

To maximise the chances of sustaining operation of off-grid electrification projects over the long term, their design must ensure that all key actors along the "value chain" - consumers, service and technology providers, financiers, and government benefit.

Until the early 1990s, the difficult local regulatory environment in the least-electrified countries, coupled with less mature technology and other factors, served to impede the development of rural electrification programmes. Support for electrification has mostly been provided to communities where connection was deemed most cost-effective, leaving remote communities, often among the poorest, the last ones connected.

Pilot projects, such as those in India and East Africa represent the first steps in demonstrating the sustained and commercial viability of deploying rural electrification in off-grid rural areas. For examples of such projects, see 'In Depth 1 – Success in Rural Electrification, Example Project in India' and 'In Depth 2 – Success in Rural Electrification, Example Project in East Africa' in Appendix 2.

A number of projects are being rolled-out, and yet an even larger opportunity for further development lies ahead.

Meeting Financing Needs

In emerging markets, financing of rural electrification projects such as a Community Power implementation will likely require the participation of both private and public stakeholders. Project developers and entrepreneurs, technology suppliers, governmental institutions, commercial banks, Multilateral Development Banks (MDBs) and International Financial Institutions (IFIs) may all be involved in financing either pilots, large scale implementation, or both. See 'In Depth 3 - Role of MDBs such as the World Bank, example in Mali' and 'In Depth 4 - Role of MDBs such as the World Bank, Example in Sri Lanka' for examples of such implementations.

For large scale project implementation, international finance institutions and multilateral development banks, such as the World Bank, are also known for providing technical and local expertise for the development of such programmes. Given that the risk/return profile of rural electrification is generally unacceptable to traditional financiers, a number of foundations and specialised investment funds are active in supporting rural electrification. For illustrative examples see 'In Depth 5 - Role of Investment Funds such as Acumen, Example in India' and 'In Depth 6 - Role of Foundations such as FRES (Nuon), Example in Burkina Faso'. For debt financing, local banks could provide an option. Carbon credits under the CDM scheme can also be considered for initial investment when they are sold forward see 'In Depth 9 - Role of CER Credits, Example of Project by DESI Power in India'.

Conclusion

- GSMA market sizing analysis indicates that there is potential for nearly 200,000 Community Power sites worldwide, with potential to impact 120 million people living in off-grid regions
- India, with more than 70,000 potential sites, has the highest potential for Community Power implementation. The potential for implementing Community Power in Africa is also high, with East Africa having strong potential as a region
- GSMA business case analysis indicates that biomass solutions are best suited for Community Power due to low cost of power generation and availability of feedstock. Wind solutions can also be attractive with external financial support
- External financial support, from entities and mechanisms such as, Multilateral Development Banks, Foundations, International Financial Institutions, specialised investment funds and carbon credits, can strengthen the business case for Community Power solutions.

3.The Community Power Opportunity in India

India's position as the world's second fastest growing economy - after China - has been aided by market liberalisation reforms within the utilities sector and strong domestic demand driven by a large population. However, large disparities in development between rural and urban areas exist. Rural infrastructure is seen as the key component in unlocking the economic and development potential of India's burgeoning rural areas.

Recently enacted reforms to generation, distribution, transmission and trading in power, by means of the Electricity Act 2003 as developed in 'In Depth 10 - Electricity Act 2003, India', have created a regulatory, financial and political environment that is favourable to Community Power projects.

Private sector investment is incentivised on a national level by government-backed schemes that include subsidies, fiscal incentives and the Rajiv Gandhi Grameen Vidyutikaran Yojna (RGGVY), a US$3.8 billion programme to promote and aid rural electrification. Strong institutional support also facilitates the Clean Development Mechanism (CDM) for rural electrification. Finally, new subsidies for renewable-based telecoms infrastructure development projects from the Indian Department of Telecoms may also provide new incentives for such investments.

Outstanding barriers to Community Power arise from the federal nature of the Government of India - making country-wide political and regulatory generalisations difficult - and the Indian constitution, which authorises both the federal and state level governments to frame electricity supply policies - complicating the work of project developers.

There is a significant opportunity for Community Power alongside base station deployment in India, with several hundred thousand new base stations expected to be built in the next few years, many of which will be off-grid. The vast proportion of India has sufficient quantities of livestock or vegetation to provide biomass energy, and wind power is possible in certain locations. The tower companies, who manage the BTS sites on behalf of the operators, will have important roles to play in the roll out of Community Power, and finding local enterprises to agree to medium term electricity off-take agreements will be critical to the financial success of any initiative. Obtaining the buy-in of the local community, particularly for the supply of biomass and for demand for electricity, is vital. The Community Power model will be able to provide electricity to the community at prices comparable or cheaper than diesel generators and kerosene, and in combination with mobile coverage, confer significant economic and social benefits to the community.

3.1 The Indian Context

India's position as the world's second fastest growing economy - after China - has been aided by market liberalisation reforms within the utilities sectors and strong domestic demand driven by a large population. However, large disparities in development between rural and urban areas exist. Rural infrastructure is seen as the key component in unlocking the economic and development potential of India's burgeoning rural areas.

Rural Electrification in India

As of 2005 India had 412 million people without access to electricity, in fact hosting the world's largest population deprived of electricity[18]. 92% of this population lives in rural India, equalling about 380 million people or 71.7 million households[19].

In 2001 the Government of India made a political commitment towards achieving the goal of 100% village electrification in a sustainable manner, as evidenced through the passage of the Electricity Act 2003 (see 'In Depth 11 - Electricity Act 2003, India'), through changes in the definition of an electrified village and through the merging of a number of Rural Electrification programmes in 2005 into one umbrella programme - the Rajiv Gandhi Grameen Vidyutikaran Yojna (RGGVY), administered through the Ministry of Power.

India's Economic Development

Since the mid-1980s, India has slowly opened up its markets through economic liberalisation. After more fundamental reforms since 1991 and their renewal in the 2000s, India has progressed towards a market-based system. Although living standards are rising fast, 75.6% of the 1.17 billion population still live on less than US$1.25 a day[20].

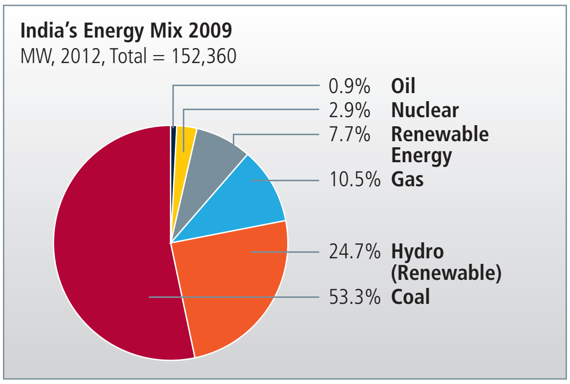
Access to modern energy services is critical to development. The provision of dependable and affordable electricity is essential for improving public health, providing modern information and education services, transitioning away from subsistence tasks and meeting India's Millennium Development Goals.

The Energy Sector and its Regulatory Environment in India

Due to India's economic rise, the demand for energy has grown at an average of 3.8% per annum between 1980 and 2006[21]. Primary energy consumption reached 566Mtoe in 2006[22] and is expected to reach 1280Mtoe by 2030. The Indian government has set an ambitious target to add approximately 78 GW of installed generation capacity by 2012[23]. The total demand for electricity in India is expected to cross 950 GW by 2030. About 75% of the electricity consumed in India is generated by thermal power plants, 21% by hydroelectric power plants and 4% by nuclear power plants[24]. See Figure 36 – Electricity Generation Mix in India, 2009.

The country has also invested heavily on renewable sources of energy such as wind energy in recent years. As of 2008, India's installed wind power generation capacity stood at 9,655 MW. In November 2009, India unveiled a US$19 billion plan to produce 20,000 MW of solar power by 2020[25].

Figure 36: Electricity Generation Mix in India, 2009



Source: Indian Ministry of Power, 2009

Electricity losses in India during transmission and distribution are extremely high and vary between 25 to 35%[18], whilst electricity demand frequently outstrips supply. Due to this shortage of electricity, power cuts are common throughout the country, adversely affecting the country's economic growth. Conversely, providing all citizens with reliable access to electricity and boosting economic growth is a top government priority.

The energy policy of India is characterised by tradeoffs between four key considerations and constraints:

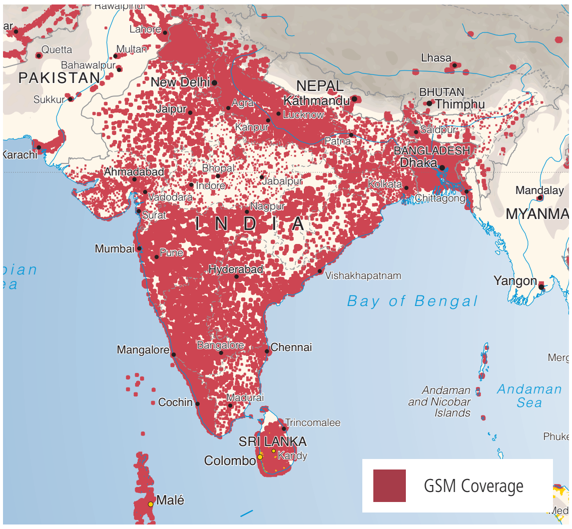
- Rapidly growing economy, with a need for dependable and reliable supply of electricity, gas, and petroleum products
- Limited domestic reserves of fossil fuels, and the need to import a vast fraction of the gas, crude oil, and petroleum product requirements, and recently the need to import coal as well
- Increasing household incomes, with a need for affordable and adequate supply of electricity and clean cooking fuels
- Urban and regional environmental impacts, necessitating the need for the adoption of cleaner fuels and cleaner technologies.

Reconciling these trade-offs has often been difficult to achieve and only 55% of Indian households are presently electrified despite a long and complex history of endeavour in rural electrification[26]. In recent years, these challenges have led the Government of India to undertake a major set of continuing reforms and restructuring, most recently through the Electricity Act 2003 (see 'In Depth 11 - Electricity Act 2003, India').

The Mobile Telecoms Sector and Its Regulatory Environment in India

The Indian Telecommunication market, in terms of number of wireless connections, is second only to China. Indeed, the total number of mobile subscribers in India has increased from 6.4 million in March 2002 to 471.5 million in Q3 2009[5], equivalent to 38.7% market penetration. India's mobile market is predicted to reach as high as 868 million subscribers (72% market penetration) by 2013[27]. Urban and rural market penetration is presently 95% and 17%, respectively[28] (see Figure 37– GSM Network Coverage in India, 2008).

Figure 37: GSM Network Coverage in India, 2008

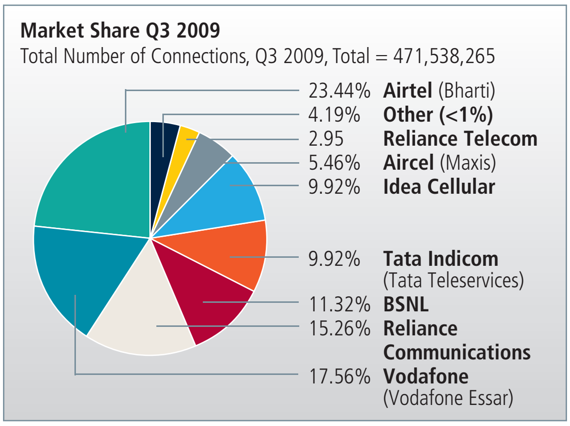


Source: GSMA and Europa Technologies Ltd.

GSM and CDMA technologies are used by 76.9% and 21.2% of mobile connections respectively[5]. Airtel, Reliance Telecom, Vodafone, Idea Cellular and BSNL/MTNL are the largest players with a total market share of 95% of the market[5], whilst many smaller players, are also in operation, typically in only a few states (see Figure 38 - Key Mobile Operators in India and Market Share, 2009).

The Government of India has been actively promoting telecoms infrastructure sharing (see 'In Depth 12 - Telecoms Infrastructure Sharing, India'). Infrastructure sharing is considered a key component in meeting forecasted telecoms demand.

Figure 38: Key Mobile Operators in India and Market Share, 2009



Source: Wireless Intelligence

The Indian telecoms market was opened to privatisation and competition in 1995. Mobile services were commercially launched in August 1995 in India following the introduction of the New Telecom Policy in 1994.

Cellular services licensing is distributed over eighteen telecoms circles and four metro cities (Delhi, Mumbai, Chennai and Calcutta). Separate licenses were given out for each of the circles in 1994. The circles were classified as Metros, A, B or C depending upon the revenue potential for the circle with Metros & A circles expected to have the highest potential.

The telecoms market is regulated by the Telecommunications Regulatory Authority of India (TRAI) and the Department of Telecom of the Ministry of Communications and Information Technology is responsible for formulating and disseminating policy and license granting for various telecoms services.

3.2 Policy Barriers and Enablers

Recently enacted reforms to generation, distribution, transmission and trading in power, by means of the Electricity Act 2003 as developed in 'In Depth 11 - Electricity Act 2003, India', have created a regulatory, financial and political environment that is favourable to Community Power projects.

Private sector investment is incentivised on a national level by government-backed schemes that include subsidies, fiscal incentives and the RGGVY, a US$3.8billion programme to promote and aid rural electrification. Strong institutional support also facilitates CDM crediting mechanisms for rural electrification. Finally, new subsidies for renewable-based telecoms infrastructure development projects from the Indian Department of Telecoms may also provide new incentives for such investments.

Outstanding barriers to Community Power arise from the federal nature of the Government of India - making country-wide political and regulatory generalisations difficult - and the Indian constitution, which authorises both the federal and state level governments to frame electricity supply policies - complicating the work of project developers.

Policy and Regulation

India has a regulatory, financial and political environment that is favourable to Community Power projects as a result of recently enacted reforms to generation, distribution, transmission and trading in power, by means of the Electricity Act 2003. Recognising the need for reforms covering the entire facets of the electricity sector comprising generation, transmission and distribution to the consumers, the comprehensive Electricity Bill was drafted in 2000 and passed in 2003. The salient features of the Electricity Act 2003 in relation to Community Power are:

- The activities of generation and distribution of electricity have been fully liberalised in rural areas, with no license requirements for market participants
- Captive generation is also freely permitted across the country
- The government of India has set for the country a target 10% renewable-based sourcing for the generation of electricity by 2012.

Demand Generation and Incentivisation for Rural Electrification

Private sector investment in rural electrification is incentivised on a national level by government-backed schemes that include subsidies, fiscal incentives and the RGGVY, a US$3.8 billion programme to promote and aid rural electrification.

Four major incentive schemes for rural electrification are available to private sector investors. They are listed below.

The Rajiv Gandhi Grameen Vidyutikaran Yojana Programme

The Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) is a scheme aimed at providing access to electricity in rural areas across the country by 2012 under the National Common Minimum Programme. Projects are financed with capital subsidy for 90% of the total project cost from RGGVY (see 'In Depth 13 - RGGVY Rural Electrification Scheme').

The Remote Village Electrification Programme

For un-electrified villages and hamlets which are not covered under the RGGVY because they are too far from the grid, the Ministry of New and Renewable Energy (MNRE) has also setup the Remote Village Electrification (RVE) programme with a US$186 million funding allocation[29]. The programme aims to provide 90% Central Financial Assistance to projects to provide renewable energy based lighting/basic electricity facilities.

IREDA Loans to the Private Sector

The Indian Renewable Energy Development Agency (IREDA) is a government owned company established in 1987 and under the administrative control of the MNRE. It provides loans to cover equipment costs of renewable energy projects. These are complemented by additional fiscal and financial incentives for a broad range of proven renewable technologies including wind and biomass. The incentives are delivered through Central Financial Assistance programmes administered by the MNRE.

Government Support to CDM Project Implementation

The Government of India has recognised the potential from CDM credits that could arise from developing a portfolio of decentralised renewable energy systems (Programmatic CDM). Accordingly, the MNRE commissioned a study in 2008 to understand and develop a framework for such programmatic CDM projects[30]. The study concluded that rural electrification projects were well suited to programmatic CDM approach but that the selection of baseline and monitoring methodology - under which a CDM Programme of Activities is designed - will be essential for successful completion of the CDM cycle. Specific problems were anticipated, including the monitoring of technical losses in distribution and transmissions and the lack of baseline data.

Finally, recent incentives programmes promoted by the Telecom Regulatory Authority of India (TRAI) may also be of relevance to the development of Community Power. These include (1) the promotion of infrastructure sharing, and most importantly (2) specific support to renewable-based infrastructure development.

- Promotion of infrastructure sharing: the TRAI subsidises infrastructure sharing by means of its Universal Services Obligation (USO) Fund, offering a significant incentive to mobile operators who share their BTS with others (see 'In Depth 12 - Telecoms Infrastructure Sharing, India')

- Support to renewable-based infrastructure development: The Government of India also offers subsidies to mobile infrastructure providers implementing pilot projects with renewable energy solutions such as solar and wind (see 'In Depth 14 - Renewable Investment Scheme, Department of Telecom, India').

Barriers to Implementation

Outstanding barriers to Community Power arise from the federal nature of the Government of India - which makes country-wide political and regulatory generalisations difficult.

Along with the restructuring and privatisation of the energy sector in India in the 1990s, the federal Central Electricity Regulatory Committee (CERC) and eighteen State Electricity Regulatory Commissions (SERCs) were set-up to regulate electricity markets, encourage competition and private investment. As electricity falls under the “Concurrent List” in the Indian constitution, both the federal and state level governments are authorised to frame policies regarding the sector, often leading to complex policy and regulatory situations that vary from state to state. Project developers have to separately negotiate with each state department, and project feasibility may often depend on state-specific policies. Furthermore, whilst the Ministry of New and Renewable Energy (MNRE) has an extensive policy structure in place, it is constrained by implementation capacity since its local agencies are often under-staffed to meet all project needs.

3.3 Commercial Structure and Implications for Stakeholders

There are many stakeholders that could be involved in Community Power – telecoms operators, tower companies, energy providers, households, local businesses, farmers, local government, banks and NGOs. This section of the report investigates how these various parties could engage with each other in India, and how the ownership and operation of a Community Power scheme could be structured. In order to set this in context, the size and nature of the market opportunity for India is detailed up front.

Market Opportunity

There is a substantial opportunity for renewable energy to provide power to base stations and rural communities in India, in a cost effective manner.

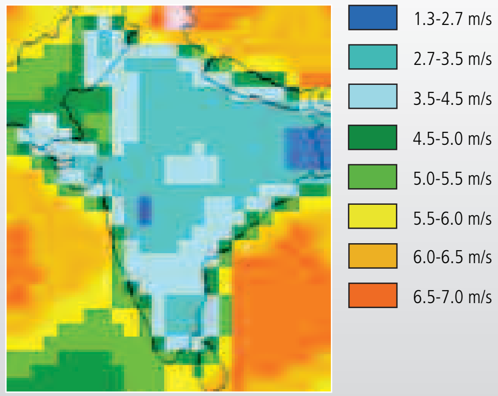
While many villages have access to electricity, not all the households in the community are connected. According to the statistics compiled in the 2001 Indian consensus, although only 44% of all homes were electrified, 86% of the rural villages have electricity. However, many of these connections are likely to be highly unreliable with limited coverage. Analysis of the Indian market together with a survey of Indian telecoms companies suggests that between 40% and 50% of new BTSs will not have access to grid electricity, which confirms the opportunity for off-grid power.

The majority of India's electricity grid is unreliable, with electricity unavailable for several hours a day. 90% of grid-connected BTS in India need diesel back-up to provide a meaningful proportion of the required electricity. As detailed in the 2008 GSMA report[7] on Green Power for Mobile, there is a large opportunity for green energy solutions to power BTS alongside unreliable grid. However, for Community Power there are the additional technical and regulatory difficulties of connecting the renewable energy source into the existing distribution infrastructure for exclusive use by the community. Moreover, as the cost of off-grid electricity is significantly more expensive than the average price of grid electricity (around US$0.10 per kWh in India), the community is unlikely to pay the higher price for marginal electricity unless it is heavily subsidised. There are plenty of areas without any grid electricity that can be prioritised.

India has a good supply of renewable energy resources:

Figure 39: Renewable Energy Resources in India

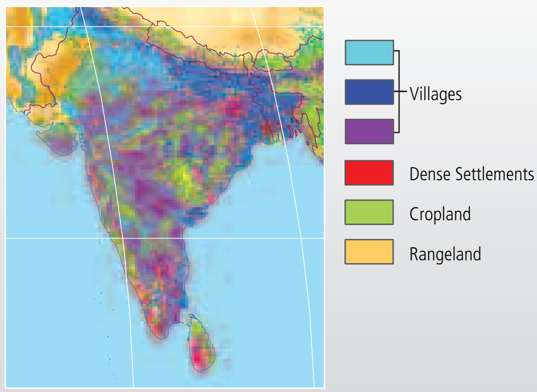
Wind Power
Area with wind speeds >5m/s and <50% downtime: **14%.**
Annual averaged from July 1983 - June 1993



Annual Average Wind Speed in India

Source: NASA/SSE

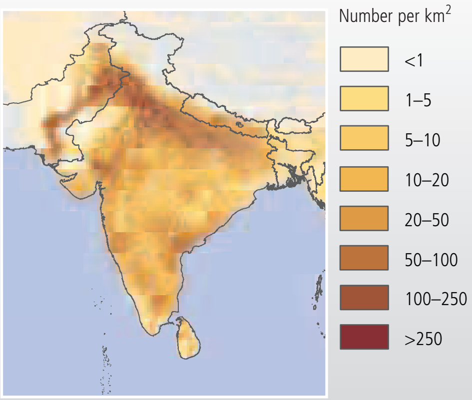
Biomass Gasification: Vegetation
Area covered by cropland, forest & villages: **86%**



Anthropogenic Biomes in India

Source: National Council for Science and the Environment

Biogas Digesters: Livestock Waste
Area with livestock density >50 km^2: **26%**



Distribution of Buffaloes in India

Source: Food and Agriculture Organisation

The market sizing analysis indicates that there is the potential for almost 70,000 green powered sites for power mobile base stations as well as providing electricity to the community. The analysis is for wind and biomass only:

Table 4 - Community Power Opportunity in India

# Viable Sites for Community Power	Wind	Biomass	Total	As % of All Off-grid BTS
Off-grid (new)	5,000	45,000	48,000	34%
Off-grid (replacement)	1,000	22,000	23,000	28%
Total	**6,000**	**67,000**	**70,000**	**32%**

Source: GSMA Research

Value Proposition for Community Power in India

This section details the "ideal" scheme for Community Power in India and is based on the business case detailed in Section 2.2.

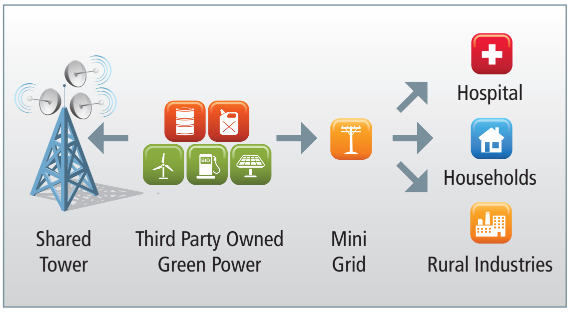
A key element of the business case is the ability to generate sufficient revenue from the electricity to cover the costs. As the initial capital outlay is a significant proportion of the overall cost of the solution, grants or subsidies to fund this CAPEX will significantly de-risk the initiative. Many Indian Community Power projects have failed in the past as the demand from the community hasn't materialised as expected.

Asset Ownership and Operation

- In India, the telecoms operators are increasingly outsourcing non-core operations, such as network management and power supply. Tower companies, many of which were originally internal divisions of telecoms operators, are typically responsible for the BTS sites, and will be important partners for any Community Power projects. There are two potential business models for the tower company:
  1. A third party, typically a specialist energy company, owns and manages the renewable energy source and the micro-grid, and sells the electricity, under a multi-year contract to the tower company, and also to the community
  2. The tower company owns and operates the renewable energy source as well as the BTS site and sells power to the community.
- In both of these cases, the tower company would need to structure a contract with the telecoms operator which incentivises the tower company to reduce the energy costs, as well as allowing the operator to share in any benefits relating to reduced energy costs.

Figure 40 outlines the first case:

Figure 40 - Stakeholder Relationships for Community Power in India



- An alternative business model is for the community or the State to own the assets. In this case, the majority of the initial funding would have to come from subsidies and grants. Whilst this would enhance the social benefits of the scheme, the implementation speed and risks may be compromised, as each community initiative will require separate negotiations, and the service levels and agreements will differ from case to case
- The businesses and households will be required to pay for the electricity and internal wiring
- Ensuring the participation and approval of the local community is essential. There have been examples in India of such community projects, where the village elders form part of a committee to oversee the operations. This committee could plan, implement, monitor and control the activities such as the maintenance and operation of the generator, and manage the billing, payment collection and disconnections
- Often, specialist local firms will be used to install the base station, the generator, and the micro-grid, as well as being responsible for any equipment maintenance or replacement.

Revenue Model

- Income from the sale of electricity can arise from a number of sources – the BTS, businesses, community projects, and households. The BTS will form an anchor tenant, but additional sources of income will be required. Established enterprises will form a more secure source of income than potential new businesses, and the likely demand and pricing of electricity will be easier to benchmark and forecast
- Typical Indian businesses may include flour mills and other food processing operations, while not-for-profit community-owned initiatives such as water pumping and distribution networks, street lighting and medical centres will also benefit from the availability of electricity
- Although it is important that the business case for Community Power is predicated on the anchor tenants, once the supply of electricity is available, this will likely spawn the establishment of new income generating activities by enabling the powering of sewing machines, machinery for drying crops, electrical equipment, computers and handset charging units
- Households will be able to use the electricity for lighting, fans and entertainment such as TV, radio and possibly computers
- Being able to forecast the expected demand and price of electricity from both households and new small businesses will be critical. Benchmarking studies and local surveys will therefore be an essential part of the due diligence.

Impact for Telecoms Operators

- The telecoms operators are unlikely to have direct ownership of the renewable energy assets, however they are set to benefit in a number of ways:
  1. Increased subscriber penetration in rural areas
  2. Increased ARPU due to availability of electricity (for handset charging) and from the positive impetus for small businesses that Community Power brings
  3. Lower site running costs
  4. Positive brand image through association with Community Power.

Renewable Energy

- Biomass, both from vegetable matter or from animal waste, is widely available in India, and has been used as the renewable energy source in this example. Supply chain issues (guaranteeing constant supply of manure or crops) are the biggest operational risk. Using crops that do not compete with food will be an important factor, and crops such as Dhaincha, which can be grown on uncultivated, waterlogged land, will be particularly well suited for India. Bio gasifiers can use diesel as an alternative fuel, which will be important to ensuring the reliability of the power supply.

Conclusion

- There is the potential for tens of thousands of Community Power sites in India, primarily based on biomass, but in certain locations wind power
- Tower companies who manage the BTS sites on behalf of the operators, will have important roles to play in the roll out of Community Power
- Finding local enterprises to agree to medium term electricity off-take agreements will be critical to the financial success of any initiative
- Obtaining the buy in of the local community, particularly for the supply of biomass and for demand for electricity, is vital
- Community Power should be able to provide electricity to the community at prices comparable or cheaper than diesel generators and kerosene, and in combination with mobile coverage, confer significant economic and social benefits to the community.

4 The Community Power Opportunity in East Africa

Since the mid-1990s, East African states have undertaken significant market liberalisation reforms in the energy and telecoms sectors to promote private investment. However, the liberalisation reforms have not produced uniform results and rural electrification rates remain below 2%. Given the dominant role of agriculture in the region's economy, rural infrastructure development and rural electrification are key for the development of the region.

Reforms of the energy sector in East Africa have removed vertically integrated state-run electricity incumbents and opened up the sector to private investors. The set-up of rural energy agencies accompanied by a strong political will to accelerate rural electrification has served to create a favourable regulatory, financial and political environment for rural electrification.

At a national level, private sector investment in rural electrification in Kenya, Tanzania and Uganda is incentivised by rural electrification institutions and funds providing subsidies, grants, country-specific fiscal policies and joint national-international project financing. These are complimented by a number of country-specific incentives.

Outstanding barriers to Community Power arise from uncertainty involving large-scale power, grid extension and interconnection projects and political risks arising from proposed federalisation of East African states.

Given that only 2% of rural households have electricity in East Africa, and mobile penetration is low, there is a significant opportunity for Community Power. Operators tend to manage their own BTS sites and there is already strong interest in deploying renewable energy at off-grid sites. Working with partners who can supply the renewable energy at the high levels of reliability required by the telecoms operators will be a key success factor. A large proportion of communities engage in agricultural businesses, and the supply of reliable amounts of electricity will likely facilitate significant improvements in their productivity.

Both biomass and wind are viable options for Community Power in East Africa, though wind solutions will require external financial support to make the business case attractive. Large wind turbines require a significant amount of diesel back up to ensure reliable supply, so given the high price of delivered diesel in East Africa, wind power will be more expensive than biomass. However, with biomass, the supply chains and the operational requirement will be more challenging.

The combination of electricity and mobile coverage will confer a range of benefits to the communities, and lead to improved levels of education, hygiene and quality of life. Although telecoms operators might take up some ownership of the initiatives in Africa (since they currently own most of the tower assets) working alongside energy companies, the role of the community in managing the day-to-day operations and creating demand for excess electricity will need to be carefully managed and incentivised.

4.1 The East African Context

East Africa comprises the five states of Burundi, Kenya, Rwanda, Tanzania and Uganda. The total population of the region is 135 million[31] and is expected to grow to 304 million by 2025[31], with a majority of the population living in sparsely electrified rural areas.

Since the mid-1990s, East African states have undertaken significant market liberalisation reforms in the energy and telecoms sectors to promote private investment. However, the liberalisation reforms have not produced uniform results and despite the region's high growth rates in mobile telecoms, rural electrification rates remain below 2%. Given the dominant role of agriculture in the region's economy, rural infrastructure development and rural electrification are crucial for the development of the region.

Rural Electrification in East Africa

The current population of East Africa lives primarily in rural areas, with only 10% of the population residing in cities, although rural-urban migrations have taken place over the last few decades.

Such a predominantly rural population and low electricity grid penetration in rural areas leads East Africa to have one of the lowest electrification rates in the world. 11% of the East African population has access to the grid across the region[32], and in effect in rural areas, electrification rates are below 2%, such that 120 million people do not have access to electricity.

In rural areas, the population relies principally on wood-based biomass as a source of energy. This, when carried out unsustainably is a major contributing factor to deforestation in the region.

East African governments have all made political commitments to address the issue of rural electrification and set near-term targets of:

- Kenya targets 22% rural electrification by 2012
- Tanzania targets 20% national electrification by 2010
- Uganda targets 10% rural electrification by 2012

East Africa's Economic Development

Kenya, Tanzania and Uganda are the largest economies of the region, and are largely free-market economies since a number of industry sectors were privatised in the mid-1990s. The five countries have also connected through the East African Community - a regional intergovernmental organisation aimed at widening and deepening political, economic and social co-operation.

Ongoing economic reforms have helped sustain positive GDP growth over the last decade. In 2008 GDP growth in East Africa averaged 7.3%, down from 8.8% in 2007[33]. Growth is expected to average 5.5% in 2009 and 2010[33].

Rural livelihoods represent an important component of the East African economies. Agriculture comprises the largest single sector contribution, accounting for 26% of GDP, 50% of export revenues and employing 70% of the total population[34].

The Energy Sector and its Regulatory Environment in East Africa

East Africa has a low level of electrification overall with 11% of households connected. In rural areas the level of electrification falls to 2% of households connected[35]. In addition, the region suffers from severe brownouts due to undersized power generation capacity and high technical losses (30-40%)[36].

Kenya, Tanzania and Uganda rely significantly on hydro power originating from slopes in the catchment area of Lake Victoria. The countries electricity grids are also interconnected, enabling Uganda to export electricity to Kenya. A new transmission line is also under development between Tanzania and Kenya.

The region's energy mix is heavily dependent upon hydroelectricity. In 2007, 62% of the electricity generated in Kenya and Tanzania came from hydropower sources[36]. In Uganda the dependence on hydro is even higher at 80%[36]. The balance is shared between thermal generating units, geothermal and bagasse-based[37] cogeneration. The high reliance on hydropower as the primary source of electricity exposes the region's economy to risks associated with seasonal variation in water availability.

Until the mid-1990s, the power sector in East-Africa was characterised by a monopoly structure, dominated by vertically integrated, state-owned power utilities. Since 1998, all of the East African countries have been undergoing power sector reforms (see Table 5 - East African Electricity Industry Reforms). These reforms have sought to minimise government involvement in the power sector and increase the participation of the private sector. Kenya, Tanzania and Uganda have all attracted Independent Power Producers (IPPs) in the power sector. Other important developments have been the unbundling of the power sectors and the creation of regulatory bodies. Tariff structures are still government-influenced and state-owned utilities monopolies cover electricity transmission and distribution.

Table 5 - East African Electricity Industry Reforms

Reform Measures	Kenya[38, 39]	Tanzania[40]	Uganda[41, 42]
Establishment of independent regulator for the power sector	■		■
Unbundling of generation and distribution	■	■	
Privatisation and commercialisation of sector	■	■	■
Enablement of independent power producers	■	■	■

The Mobile Telecoms Sector and its Regulatory Environment in East Africa

East Africa is the telecoms market with the highest increase in penetration rate in the world. The total number of mobile phones connections in East Africa was 1.4 million[5] in 2002 and has grown to 30 million[5] in 2009, representing a compounded average growth rate of 55%. The average mobile penetration over the population of East Africa is presently 22%. The number of mobile phone connections is expected to increase to 90m by 2013[5].

Fourteen operators are active in East Africa (see Table 6 - Telecoms Operators in East Africa). The region is also home to the world's first borderless mobile phone through the East African Alliance's "Kama Kawaida" scheme involving Safaricom, MTN Uganda, Vodacom Tanzania, MTN Rwanda, UCOM of Burundi, and Uganda Telecom. Kama Kawaida allows subscribers to roam at no extra cost across East Africa.

Table 6 - Telecoms Operators in East Africa

Telecoms Operator	Kenya	Tanzania	Uganda
BOL Mobile		■	
Essar Telecom	■		
I-Tel			■
MTN			■
Orange	■		■
Safaricom	■		
Sasatel		■	
Tigo Millicom		■	
TTCL		■	
Uganda Telecom			■
Vodacom		■	
Warid Telecom			■
Zain	■	■	■
Zantel - Etisalat		■	

Source: Wireless Intelligence

The telecoms sector in East Africa is now characterised by a highly competitive marketplace following the introduction of liberalising regulation and issuance of multiple operator licences.

Telecoms Market Highlights for Kenya

- Kenya has four mobile operators with a total market penetration of 53.4%[5]. The operators' interests are represented by the Telecommunications Service Providers Association of Kenya (TESPOK), a professional, non-profit organisation
- Telecoms market regulation is overseen by an independent regulatory authority called the Communications Commission of Kenya. The commission supports the implementation of the 2008 Kenya Communications Amendment that simplified the licensing rules for telecoms operators and allowed for convergence. This led to lowering the barriers to entry and increasing competition by allowing operators to offer any kind of service in a technology- and service-neutral regulatory framework.

Telecoms Market Highlights for Tanzania

- Tanzania has seven mobile operators with a total market penetration of 42.6%[5]
- Telecoms market regulation is overseen by an independent regulatory authority called the Tanzania Communications Commission (TCC). The commission supports the implementation of the 1993 Tanzania Communications Act to liberalise and introduce competition into the communications sector, remove Government as a major investor and operator and establish the TCC as independent regulator
- Tanzania was one of the earliest African countries to fully liberalise its communication sector following expiring of exclusivity rights given to incumbent Tanzania Telecommunications Company Limited in 2005. A converged licensing regime, introduced in 2006, has brought a large number of new players into the market.

Telecoms Market Highlights for Uganda

- Uganda has six mobile operators with a total market penetration of 36.4%[5]
- Telecoms market regulation is overseen by an independent regulatory authority called the Uganda Communications Commission which provides regulation, licensing and tariff structuring. The commission supports the implementation of the Communications Act of 1997.

Uganda was one of the first countries in Africa to develop a policy on universal access to modern communications. The Rural Communications Development Fund (RCDF) was launched in 2001 in order to motivate and mobilise private sector investment into rural areas by offering subsidies and grants that act as investment incentives. The fund is the result of a one per cent levy on operators.

4.2 Policy Barriers and Enablers

Reforms of the energy sector in East Africa since the late 1990s have removed vertically integrated state-run electricity incumbents and opened up the sector to private investors. Concomitant set-up of rural energy agencies and a strong political will to accelerate rural electrification have served to create a favourable regulatory, financial and political environment for Community Power.

At a national level, private sector investment in rural electrification in Kenya, Tanzania and Uganda is incentivised by rural electrification institutions and funds providing subsidies, grants, country-specific fiscal policies and joint national-international project financing. These are complimented by a number of country-specific incentives.

Outstanding barriers to Community Power arise from uncertainty involving large-scale power, grid extension and interconnection projects and political risks arising from proposed federalisation of East African states.

Policy and Regulation

Energy policy within the East African states is guided by energy legislation introduced in the late 1990s and onwards. The reformed energy policy of Kenya, Tanzania and Uganda has introduced - to differing degrees - liberalisation of generation, distribution, transmission and power trading components of the electricity sector. With respect to rural electrification, the key features enabled by the reforms are:

Key Policy, Institutional, Regulatory and Licensing Elements of Kenya

- Rural electrification has been enabled by the Electrical Power Act of 1997 and Energy Act 2006
- The Energy Act 2006 established the Rural Electrification Authority to promote privately or community owned energy service entities operating renewable energy power plants and hybrid systems
- The Energy Act 2006 instated the Energy Regulatory Commission, a single sector regulatory agency replacing the Electricity Regulation Board, with responsibility for regulation for power and renewable energy, including tariff setting and review, licensing, enforcement, dispute settlement and approval of power purchase and network service contracts.

Key Policy, Institutional, Regulatory and Licensing Features of Tanzania

- Rural electrification has been enabled by National Energy Policy 2003, Rural Energy Act 2005 and the Electricity Act 2008
- The Rural Energy Act 2005 established the Rural Energy Board, Rural Energy Fund and Rural Energy Agency. The Agency and Fund provide grants and subsidies to developers of rural energy projects
- Regulation of Tanzania's energy sector is overseen by the Energy and Water Regulatory Authority (EWURA) which became operational in 2006. EWURA is an autonomous multi-sectoral regulatory authority responsible for regulation of the electricity, petroleum, natural gas and water sectors, and charged with administering the Electricity Act 2008 and facilitating fast electrification and access in rural regions. The Electricity Act 2008 has liberalised the electricity generation, transmission and distribution sector and provides for cross-border trade in electricity, and regulation of rural electrification.

Key Policy, Institutional, Regulatory and Licensing Features of Uganda

- The Electricity Act 1999 defines the current legal framework for energy sector reform and enables and supports rural electrification. The Act ended the monopoly of the state utility, the Uganda Electricity Board (UEB), breaking it up into three companies. Generation and transmission are semi-privatised through long term concessions, while distribution remains in public ownership
- Renewable energy is supported by the Energy Policy for Uganda 2002 and Renewable Energy Policy 2007. The former provides the framework for meeting the energy needs of the Ugandan population partly through renewable energy sources. The latter was introduced to maintain and improve the responsiveness of the legal and institutional framework to promote renewable energy investments, establish an appropriate financing and fiscal policy framework, and promote the sustainable production and utilisation of bio-fuels
- The Electricity Act 1999 mandated the instatement of the Electricity Regulatory Authority for the purpose of providing regulation, licensing and tariff setting in Uganda. Section 113 of the Electricity Act enables the Electricity Regulatory Authority, for the purposes of promoting rural electrification, to exempt a potential licensee for the generation / distribution and sale of electricity from the requirement to hold a licence where such generation does not exceed two megawatts.

Demand Generation and Incentivisation for Rural Electrification

At a national level, private sector investment in rural electrification in Kenya, Tanzania and Uganda is incentivised by (1) rural electrification institutions and funds providing subsidies, grants; (2) country-specific fiscal policies; (3) joint national-international project financing; and (4) a number of other country-specific incentives.

Incentivisation of Rural Electrification in Kenya

The Rural Electrification Authority became operational in 2007. The Authority are responsible for managing the Rural Electrification Programme Fund, implementing and sourcing additional funds for the rural electrification programme, promoting the use of renewable energy sources and managing the delineation, tendering and award of licences and permits for rural electrification.

The Authority's Five Year Strategic Plan aims to achieve 22% rural electrification by 2012. To date they have allocated US$48 million in funds to constituencies across Kenya. In addition, they will match constituency contributions up to US$67,000 for construction projects that require installation of transformers or short power lines. For 2010 a total of US$107.6 million has been allocated for rural electrification projects.

Incentivisation of Rural Electrification in Tanzania

The Rural Energy Board (REB), the Rural Energy Agency (REA), and the Rural Energy Fund (REF) were established under the Rural Energy Act and entrusted with the role of promoting, stimulating and facilitating improved access to modern energy services in rural areas through empowering both public and private sector initiatives in rural energy.

The Rural Energy Fund supplies grant payments and financial disbursements through the Tanzanian Investment Bank. The Fund provides resources for:

- Grants towards the capital costs of projects implemented by private and public entities, co-operatives, and local community organisations
- Provisioning of technical assistance, training and other forms of capacity building to qualified developers by qualified experts related to the planning and preparation of a project prior to an application for a grant
- Co-financing of investments in innovative pilot and demonstration projects and applications for renewable energy.

Tanzania has simplified procedures for investing in solar, wind and micro-hydro projects including a 100% depreciation allowance in the first year of operation, exemption from excise duty and sales tax and concessionary customs duty on the first import of materials used in renewable energy projects. Also, the Universal Communications Services Act of 2006 established Universal Communication Access Fund (UCAF) to encourage the participation of the private sector in the provision of access to communications services in the rural and underserved communities in Tanzania. The UCAF provides "smart" subsidies to encourage the private sector to invest in areas which are commercially non-viable.

The Tanzania Energy Development and Access Expansion Project (TEDAP) is implemented by the Ministry of Energy and Minerals in collaboration with REA and state utility Tanzania Electric Supply Company Limited (TANESCO). TEDAP is funded by World Bank and GEF and runs from April 2008 to June 2012. TEDAP aims at increasing the electricity access in rural and peri-urban Tanzania. Support facilities for project developers available from TEDAP include (1) Performance grants – US$500 for each new connection in rural areas using renewable energy sources, (2) Matching Grants and (3) technical and capacity building assistance.

Incentivisation of Rural Electrification in Uganda

The institutional mechanisms for funding, planning and coordination of rural electrification in Uganda are overseen by the Rural Electrification Board (REB). The Rural Electrification Agency (REA) is the implementing agency and serves as the REB Secretariat. REA facilitates and promotes rural electrification and renewable energy projects of 20MW or less. Currently the REA administers the Rural Electrification Fund, subsidising investments in rural electrification for:

- Expansion of the main grid
- Development of isolated and mini-grid systems for relatively concentrated areas with a potential for productive use
- Solar PV systems.

Uganda provides investment incentives and guarantees to investors including tax incentives, accelerated depreciation, and foreign exchange repatriation measures. Other incentives include a credit support facility and a Build-Own-Operate arrangement for generation projects up to 10MW. The government has also removed all taxes on solar equipment and is in the process of availing a 0 per cent tax for fuel to generators above 100 kVA.

In Uganda, the Energy for Rural Transformation Project (ERT) is a long-term programme to develop rural areas underwritten by a three-phase Adaptable Programme Loan. Phase II of ERT runs from April 2009 to July 2013 and is supported by US$75 million of International Development Association credit plus a Global Environment Facility grant of US$9 million. The objective of the project is to increase access to energy and information and communication technologies in rural regions to contribute to the productivity of enterprises and the quality of life of households. See ‘In Depth 15 – Energy for Rural Transformation Project (ERT), Uganda’ for more details

Barriers to Implementation

Outstanding barriers to Community Power arise from (1) uncertainty involving large-scale power, grid extension and interconnection projects and (2) political risks arising from proposed federalisation of East African states.

Uncertainty Involving Large-scale Power, Grid Extension and Interconnection Projects

A number of regional power and interconnection projects are in planning or construction stage. A US$282 million regional power interconnection project has been announced as part of the Nile Equatorial Lakes Subsidiary Action Programme. The project will link the electricity networks of countries in the Nile Equatorial lakes region and entail the construction and strengthening of the electricity networks in Burundi, Democratic Republic of Congo, Kenya, Rwanda and Uganda over 2011-2014. In Uganda, the Bujagali Hydropower Project and related Bujagali Interconnection Project and the recent discovery of oil also introduce uncertainty over the cost effectiveness of decentralised power solutions.

Political Risks Arising from Proposed Federalisation of East African States

As members of the East African Community, Kenya, Tanzania and Uganda are members of the East African Community Customs Union. As per recent reports in the media[43], introduction of common markets and single currency in East Africa is quite possible in the near future. The proposed future federalisation would produce a marked shift in policy, fiscal and financial arrangements within the region.

4.3 Commercial Structure and Implications for Stakeholders

There are many stakeholders that could be involved in Community Power – telecoms operators, tower companies, energy providers, households, local businesses, farmers, local government, banks and NGOs. This section of the report investigates how these various parties could engage with each other in East Africa, and how the ownership and operation of a Community Power scheme could be structured. In order to set this in context, the size and nature of the market opportunity for East Africa is detailed up front.

Market Opportunity

There is a large opportunity for renewable energy to power base stations and communities in rural Kenya, Tanzania and Uganda in a cost effective manner.

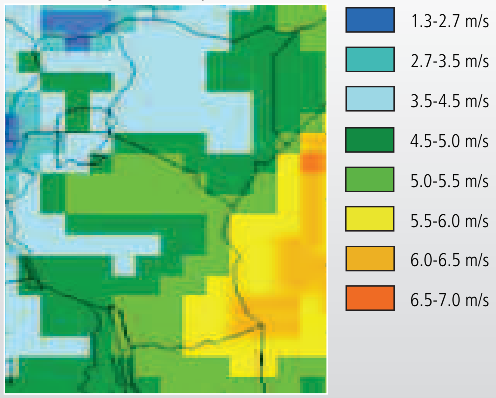
In East Africa 89% of the population does not have access to grid electricity[32] and there is barely any grid coverage in rural areas.

The majority of existing base stations are located off-grid and the total number of off-grid base stations is likely to increase significantly as new mobile networks get rolled out.

Eastern Africa has a good supply of renewable energy resources:

Figure 41: Renewable Energy Resources in East Africa

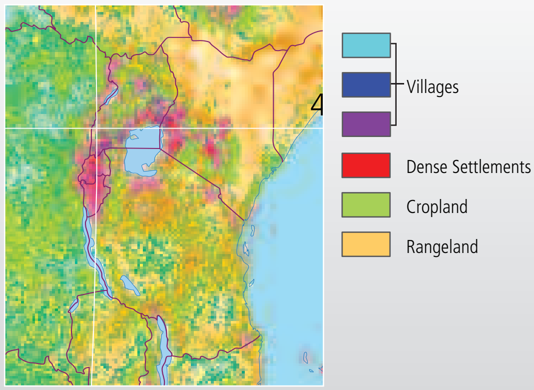
Wind Power
Area with wind speeds >5m/s and <50% downtime: **23%**
Annual averaged from July 1983 - June 1993



Wind Speed in East Africa

Source: NASA

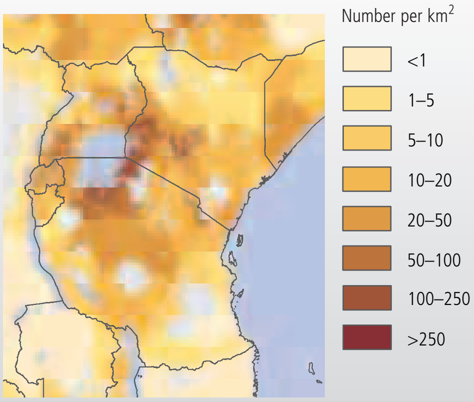
Biomass Gasification: Vegetation
Area covered by cropland, forest & villages: **42%**



Anthropogenic Biomes in East Africa

Source: National Council for Science and the Environment

Biogas Digesters: Livestock Waste
Area with livestock density >20 km^2: **19%**



Cattle Density in East Africa

Source: Food and Agriculture Organisation

The market sizing analysis indicates that there is the potential for almost 11,000 renewable energy powered sites for mobile base stations and community electricity.

The following table shows the opportunity for wind and vegetation biomass sites:

Table 7 - Community Power Opportunity in East Africa

# Viable Sites for Community Power	Wind	Biomass	Total	As % of all off-grid BTS
Off-grid (new)	1,100	3,700	4,100	16%
Off-grid (replacement)	1,000	6,100	6,600	42%
Total	**2,100**	**9,800**	**10,700**	**25%**

Source: GSMA Research

Value Proposition for Community Power in East Africa

Whereas the case study for India was based on a biomass solution, this example will use wind as the renewable energy source. Compared to India, a site in East Africa is almost twice as likely to be suitable for wind-based Community Power, while the concentration of biomass is much lower. However, according to the business case for wind-based Community Power solution (see Section 2.2), external financial support will be required to make the business case attractive. The choice of wind as the renewable energy source in this example is arbitrary. For example, biodigesters, fuelled with manure, also represents a meaningful opportunity in East Africa and projects of a similar scale have been successfully demonstrated in the past. A large proportion of East Africa's rural population are animal farmers.

Asset Ownership and Operation

- In East Africa, particularly when compared to India, the telecoms operators have outsourced fewer of their activities, particularly around infrastructure. The operators are likely to be more prominent stakeholders in any Community Power projects, and are more likely to directly invest in and initiate such projects
- However, although the operators typically own and operate the base stations, they are less likely to own and operate renewable energy systems, and would look to form relationships with third party providers. Finding providers who are sufficiently reliable and experienced to provide the operators with the required levels of guarantees and comfort is a key risk. These third party providers would also be responsible for installing and maintaining the equipment, but may lack the required expertise to build and maintain the micro-grid to distribute the electricity to the community.

Revenue Model

- The source of revenue for a Community Power project in Africa will be similar to the other business cases laid out in this report. The BTS will form an anchor tenant, and finding businesses to be reliable consumers of electricity will again be a key element. Given the widespread nature of agricultural business across East Africa, many of the opportunities are likely to be agriculture-related, such as milk cooling systems.

Communities

- Up to 40% of East Africa's rural population may be nomadic, which reduces the number of opportunities for Community Power. Finding communities which are densely populated will provide the most attractive opportunities. Given the tribal nature of communities, ensuring that the village chiefs support and benefit from the initiatives will be critical. Wind solutions need much less operational input than biomass, which require members of the local community to be trained up, committed to operating the systems, and committed to providing adequate sources of fuel.

Impact for Telecoms Operators

- Given that the African operators are directly responsible for the BTS sites, and that although there is some site swapping agreements, there is limited sharing of BTS sites with competitors, the branding and PR effects will be marginally greater than in India. Benefits to the operators include:
  - Increased subscriber penetration in rural areas
  - Increased ARPU due to availability of electricity (for handset charging) and from the positive impetus for small businesses that Community Power brings
  - Lower site running costs, and potentially more control over the reliability of the energy
  - Positive brand image through association with Community Power.

Conclusion

- Given that only two per cent of rural households have electricity in East Africa and mobile penetration is rapidly growing, there is a significant opportunity for Community Power. GSMA market sizing analysis has estimated a potential for nearly 11,000 Community Power sites across East Africa
- Both biomass and wind are viable options for Community Power in East Africa, though wind solutions will require external financial support to make the business case attractive due to significant amount of diesel backup
- Mobile operators typically manage their own base station sites and therefore will be the primary stakeholder in any Community Power implementation. Working with partners who can supply renewable energy at high levels of reliability will be a key success factor
- A large proportion of communities engage in agricultural businesses and a reliable supply of electricity will facilitate significant improvements in their productivity
- The combination of electricity and mobile coverage will confer a range of benefits to communities and lead to improved levels of education, hygiene and quality of life
- The role of the community in managing day-to-day operations and creating demand for excess electricity will need to be carefully managed and incentivised.

Glossary of Terms

Ah / Ampere-hour - unit of electric charge, the electric charge transferred by a steady current of one ampere for one hour

ARPU - Average Revenue per User

BTS / Base Transceiver Station - the name for the antenna and radio equipment necessary to provide mobile service in an area

BAU - Business as usual

Brown out - a drop in voltage in an electrical power supply

CAPEX - Capital Expenditure

Carbon footprint - Impact of human activities on the environment in terms of GHG produced, measured in CO2e

CDM / Clean Development Mechanism - an arrangement under the Kyoto Protocol allowing industrialised countries with a greenhouse gas reduction commitment to invest in ventures that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries

CDMA / Code Division Multiple Access – a mobile communication technology

CER / Certified Emission Reductions - a tradable credit representing GHG emission reductions equivalent to one tonne of CO2e achieved through a CDM project

CERC - Central Electricity Regulatory Commission

CO2 - Carbon dioxide

CO2e - Carbon dioxide equivalent

Distributed generation - Generation of electricity from small energy sources

DOE / Designated Operational Entity - independent auditors that assess whether a potential CDM project meets all the eligibility requirements (validation) and whether the project has achieved greenhouse gas emission reductions (verification and certification)

Embedded carbon - Total CO2e required to get a product to its position and state. Includes product manufacture, transport and disposal

Emerging markets - Business and market activity in industrialising or emerging regions of the world

ERT - Ugandan Energy for Rural Transformation

ERTRF - Ugandan Energy for Rural Transformation Refinance Fund

GDP - Gross Domestic Product

GEF / Global Environment Facility - a global partnership among 178 countries, international institutions, non-governmental organisations, and the private sector to address global environmental issues while supporting national sustainable development initiatives

GHG - Greenhouse gas

GPRS / General Packet Radio Service – a mobile data communication technology

GPS / Global Positioning System - the only fully functional global navigation satellite system. Utilising a satellite constellation of at least 24 medium earth orbit satellites that transmit precise microwave signals, the system enables a GPS receiver to determine its location, speed, direction and time

GPM - GSMA Green Power for Mobile

GSM - Global System for Mobile communications

GSMA - GSM Association

Gt / Gigatonne - equal to one billion tonnes

GW / Gigawatt - equal to one billion Watts

ICT / Information and Communications Technology - Combination of devices and services that capture, transmit and display data and information electronically

IDA / International Development Association - a part of the World Bank that helps the world's poorest countries

IEA - International Energy Agency

IEG - World Bank's Independent Evaluation Group

IFC - International Finance Corporation (a member of World Bank Group)

IFI / International Financial Institutions - financial institutions that have been established (or chartered) by more than one country, and hence are subjects of international law

IPCC / Intergovernmental Panel on Climate Change - Scientific inter-governmental body set up to assess the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation

IPP / Independent Power Producer - an entity, which is not a public utility, but which owns facilities to generate electric power for sale to utilities and end users

IREDA - Indian Renewable Energy Development Agency Limited

IRR - Internal Rate of Return

kVA / Kilovolt-Ampere - the unit of apparent power kVA is used for measuring the power consumption of non-resistive equipments such as generators

kW / Kilowatt - a unit of power equal to a thousand Watts

kWh / Kilowatt hour - a measure of energy capable of providing a kilowatt of power for one hour

Kyoto Protocol - Legally binding agreement of the UNFCCC in which industrialised country signatories will reduce their collective GHG emissions by 5.2% on 1990 levels. Negotiated in December 1997 in Kyoto, Japan, and came into force in February 2005

LCA / Life Cycle Analysis - also known as life-cycle assessment

MDGs / Millennium Development Goals - Eight international development goals that 192 United Nations member states have agreed to achieve by the year 2015

MFP / Multi Function Platform - is an engineering and technological approach to using local available biomass residues to produce shaft horsepower, electricity, and heat to support economically productive activities in rural communities

MNRE / Ministry for New and Renewable Energy - Government of India

Mt / Megatonne - one million tonnes

Mtoe / Million tonne of oil equivalent - a unit of energy equal to the amount of energy released by burning one million tonnes of crude oil

MW / Megawatt - equal to one million Watts

NGO - Non Governmental Organisation

OPEX - Operating Expenditure

RERED - Renewable Energy for Rural Economic Development Project, Sri Lanka

RGGVY - Rajeev Gandhi Grameen Vidyutikaran Yojana

SERC - State Electricity Regulatory Commission

S**HREY -** SBA Hydro and Renewable Energy Pvt Ltd

SHS - Solar Home Systems

SIDA - Swedish International Development Cooperation Agency

SIM / Subscriber Identity Module - typically on a removable SIM card that securely stores the service-subscriber key used to identify a subscriber on mobile telephony devices (such as computers and mobile phones)

SMS / Short Message Service - Communications protocol allowing the interchange of short text messages between mobile telephone devices

PV / Photovoltaic - in this instance refers to solar PV cells which convert visible light into direct current

TANESCO - Tanzania Electric Supply Company Limited (TANESCO) is a Tanzanian parastatal organisation

TEDAP - Tanzania Energy Development and Access Expansion Project

TRAI / Telecom Regulatory Authority of India - Independent regulator established by the Government of India to regulate the telecommunications business in India

USO / Universal Service Obligation - obligation to provide access to basic telecoms services to people in rural and remote areas at affordable and reasonable prices

UNFCCC / United Nations Framework Convention on Climate Change - Adopted in May 1992, signed by more than 150 countries at the Earth Summit in Rio de Janeiro. Its ultimate objective is the "stabilisation of GHG concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." Came into force in March 1994 and is ratified by 192 countries

W / Watt - a unit of electrical power equal to one ampere under a pressure of one volt

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1. Community Power Case Studies

Safaricom Community Power Site at Tegea, Kenya (Operator-owned, Diesel Power)

Tegea is a small village tucked away in a remote corner of Mau forest region in Kenya's renowned Rift Valley, about 250 km North-West of Nairobi. The village is hard to access – one has to drive nearly half of the 70 km distance from the nearest town of Molo on a rocky country road.

As with thousands of other villages in Kenya, the national electricity grid has still not reached Tegea. However, the situation hasn't been the same since Safaricom, Kenya's largest mobile operator, decided to setup one of its ubiquitous sites in the middle of Tegea.

The site's design and logistical considerations necessitated the installation of power equipment with capacity well above the site's peak power load. It wasn't too long before Safaricom realised that the community of Tegea could immensely benefit from the excess power generation capacity available at the site. There were several issues – regulatory, technical and business – that had to be resolved before the Tegea Community Power infrastructure was setup.

Regulatory

As in most developing countries, power distribution to retail consumers is restricted in Kenya, with the state-owned Kenya Power and Lighting Company (KPLC) being the sole authorised power distributor in the country. However, this regulation has been relaxed for small-scale rural community applications. Safaricom requested Tegea's community to present an appeal for electricity, which was used to obtain the necessary clearance from the government.

Technical & Business

Safaricom considered various design factors such as technical feasibility, business sustainability and community impact. The primary technical/business factor was of course ensuring that their site's power requirement was not compromised. This was achieved by introducing circuit breakers into the site's design, which disconnect the power supply if the Community Power load exceeds a certain level.

Two months after the project was initially conceptualised, a handset charging dock with about 12 power plugs, a network of six street lights in the village's main market street and power to a local church were provided. Power to the site's landlord's house and the village chief's house was also provided.

Impact

The benefits to Tegea's community have been immense. The handset charging dock at the site has eliminated the villagers' need to walk for three hours to the town of Molo just to charge their handsets. Safaricom has also benefited from this move since availability of handset charging has resulted in higher utilisation of Safaricom's services which in turn means higher revenues. Additionally, the availability of street lighting in Tegea's main street has made post-sunset commercial activity possible. A local vendor, who runs a small grocery store on the street, who used to shut down the store's shutters by 6 PM every evening earlier, now keeps it open until 8.30-9.00 PM. Another vendor, who runs a small eatery on the street, says that with the availability of street lights, she now feels safe enough to keep her eatery open until midnight. This feeling of increased safety has extended throughout the community. Safaricom and Philafe Engineering, who maintain the site, have observed a marked reduction in theft and vandalism at the site since installing the Community Power infrastructure. They believe that this is due to the fact that the local community now has the right incentive to safeguard the site.

Grameenphone Community Power Site at Gazipur, Bangladesh (Third Party-owned, Green Power)

Gazipur is a small town within the mostly rural district of the same name, located about 60 km North of Dhaka in Bangladesh. The town is hard to reach since the journey from Dhaka to Gazipur requires one to drive 30 km on the National Highway and a further 30 km on country roads.

As with nearly 55%[44] of Bangladesh's rural areas that do not have access to electricity, the national electricity grid has still not reached Gazipur. Until January 2008, Gazipur used to plunge into darkness every evening. However, the situation hasn't been the same since Dream Power, a distributed renewable energy supply start-up company, decided to setup a trial biomass gasifier power plant to supply electricity to the local Grameenphone (Bangladesh's leading mobile operator) base station as well as to Gazipur's local community.

The Grameenphone site in Gazipur, which is an indoor site with an average power load of 6kW, was setup in July 2007, powered by two 30 kVA diesel generators (one of them is used as a back-up). However, when Dream Power setup a 250 kW rice husk-based biomass gasifier plant in the area in early 2008, Grameenphone decided to draw power from this plant.

There were several regulatory, technical and business considerations before the Gazipur Community Power infrastructure was setup.

Regulatory

As in most developing countries, power distribution to retail consumers in Bangladesh is a market which is monopolised by several state-owned utilities such as Dhaka Energy Supply Company (DESCO) and Rural Electrification Board (REB). However, the Government offers power distribution license exemptions to small scale renewable energy based energy suppliers. Dream Power took advantage of this exemption while implementing Community Power applications at Gazipur.

Technical & Business

The rice husk-based biomass gasifier plant was conceptualised and implemented by Dream Power. At present, the plant's biomass gasifier runs for about six hours a day, from 6 PM to 12 AM, since this is the period when the local community draws the highest amount of power, ensuring high Plant Load Factor (PLF). The Grameenphone base station draws power from the biomass plant for these six hours, which also charges the site's batteries. The base station runs on batteries and diesel generators for the remaining eighteen hours of the day.

Before the biomass plant was setup, the diesel generators at the Grameenphone site used to run for nearly nine hours a day. Now, they run for about two hours a day. Running the site on diesel generators costs Grameenphone about 40 Bangladeshi Takas (US$0.60) per kWh unit of electricity, whereas running the site on power supplied by the biomass plant costs Grameenphone about 8 Takas (US$0.12) per kWh unit, which is very close to the cost of grid electricity, which is about 5.3 Takas (US$0.08).

Since Grameenphone's site reliability requirements are very high, ensuring uninterrupted power supply from the biomass plant was an important design consideration for Dream Power. This criterion has been met by positioning its personnel at the site at all times. The company has also developed strong relationships with the local community which provides a steady supply of feedstock to the plant. According to Grameenphone, the plant has always delivered on its service level agreements.

The plant currently provides electricity for lighting and other applications to nearly 300 households, within a distance of 10 km from the Grameenphone site in Gazipur. Power is also provided to a few street lights near the plant as well as to a poultry farm in the neighbourhood. Each of the households and the poultry farm have been installed with equipment for monitoring usage and billing, with the community paying slightly less per unit of electricity (US$0.08) than Grameenphone.

In spite of these power uptakes, the total power load from all the applications including the Grameenphone site is only at around 60-70 kW, whereas the power plant's peak capacity is 250 kW, representing a mere 25-30% PLF. This oversizing of the plant is perhaps the main reason why it is still not profitable, since at these PLFs, costs of operation of the plant cannot be recovered. Transmission losses due to long distances (up to 10 km) also contribute to the plant's inefficient operation.

Impact

Availability of power for lighting and other applications in the evening has resulted in a large increase in commercial and social activity in the area, thus improving the quality of life immensely. It has also improved the conditions for local children to study in the evening, thus improving their quality and levels of education.

2. In Depth Sections in this Whitepaper

In Depth 1 – Success in Rural Electrification, Example Project in India

Ranidhera Rural Electrification Project, undertaken by Winrock International India, provides electricity to all 105 households in the village for three hours a day. Power is provided by a Jatropha-run power plant housed in a small building in the village. The plant has three generator sets of 3.5 kVA and a backup generator of 7.5 kVA.

Since May 2007 the villagers have been paying 20 Rs (US$0.42) per light point per month and 30 Rs (US$0.64) per socket per month into a Village Energy Fund. Financial support was provided by the Ministry for New and Renewable Energy, the British High Commission, and the Swiss Agency for Development and Cooperation.

In Depth 2 – Success in Rural Electrification, Example Project in East Africa

Two villages in the Monduli District of Tanzania have received Multi Function Platforms (MFP) supplying electrification for the local community and businesses. The MFPs use diesel and Jatropha oil to provide electricity for lighting, powering grain milling machines, battery and mobile phone charging.

The project was enabled through US$31,000 of support from the GAP Fund programme, managed by the Global Village Energy Partnership (GVEP). A Tanzania based NGO, Tanzania Traditional Energy Development, and an environment organisation (TaTEDO), installed the MFP.

Jatropha is already grown in the target area and Jatropha oil is used as fuel for lighting and cooking and as a raw material in soap manufacturing. MFPs can increase demand for Jatropha oil and stimulate mass production of the crop creating more of a market and a greater income for the farmers.

Project results: (1) At least 112 households were able to connect to the electricity mini-grid for lighting, out of which 30 households ran small businesses; (2) Twenty entrepreneurs were helped to develop businesses using electricity and mechanical power from the MFPs; (3) More than 5,000 individuals gained access to milling, dehusking and pressing in villages; (4) Women participated in decision making and implementation; and (5) Incomes increased through the creation of new businesses such as barber shops, phone charging and a market for Jatropha seeds.

In Depth 3 - Role of MDBs such as the World Bank, Example in Mali

In Mali, only about 7% of the rural population has access to electricity. Most rural households meet their lighting and small energy needs with wood, charcoal, kerosene, dry cells and car batteries. Most villages in Mali with a school or health centre are without any form of energy for lighting or for operating equipment. The World Bank–financed Mali Household Energy and Universal Rural Access Project, introduced in 2003, has assisted the installation of 2,350 solar home systems and 636 public institutions.

Capitalising on past experiences, the Household Energy and Universal Rural Access Project was designed to increase access of isolated low-income populations to basic energy services and to accelerate the use of modern energies in rural areas in order to increase the productivity of small and medium enterprises, and to enhance the quality and efficiency of health and education centres. Overall International Development Aid (IDA) financing from the World Bank is US$35.6 million, with a US$3.5 million GEF grant, and US$5.25 million from the Government of Mali. In September 2008, additional financing of US$35 million was approved by the World Bank to further support the project.

Local private operators are the driving force of the project. They benefit from technical assistance from AMADER, the rural energy agency, and from financing through a rural electrification fund set up by the project.

Solar PV initiatives are being implemented in remote rural communities far from the main grid, in about 40 communities, and about 2,350 solar home systems have been installed. In these regions, about 636 public institutions— such as city halls, administrative offices, and community centres, including 40 schools and 48 health centres—are also powered by solar. The availability of energy services in rural communities is an important catalyst to the Government of Mali’s administrative decentralisation initiatives.

In Depth 4 - Role of MDBs such as the World Bank, Example in Sri Lanka

Since 2002, the Renewable Energy for Rural Economic Development (RERED) Project in Sri Lanka, with US$75 million in IDA credits and US$8 million in GEF grants, has supported private-sector investment in an additional 85 MW of grid-connected, renewable-energy electricity generation, more than 100,000 solar home systems (SHS), and independent micro hydropower grids. In 2007, an additional US$40 million in IDA financing was provided to support another 50,000 off-grid connections and 50 MW of renewable energy, electricity-generation investments. Implementing the private sector–led renewable energy programme has created a vibrant local industry of suppliers, developers, financiers, consultants, and trainers. By June 2008, some 120,000 households were using SHSs, with 750 new installations occurring monthly. Nearly 6,000 households are obtaining electricity from micro-hydro mini-grids that communities own, operate, and manage. 100 MW of mini-hydro and biomass based–powered grid-connected plants are in operation and contributing 4% of electricity to the national grid. Another 25 MW are under construction.

As part of their rural electrification programmes, governments of developing countries have offered funding or established a rural energy fund for private-sector or nongovernmental organisations. Governments typically subsidise a portion of the capital cost, while the community or private sector covers the balance investment cost and full cost of operation and maintenance. See 'In Depth 13 - RGGVY Rural Electrification Scheme, India'. Assistance in implementing or financing the rural electrification ambitions of the developing countries has also been provided by multilateral aid (see 'In Depth 8 - Role of multilateral aid Funds such as SIDA, example in Tanzania').

In Depth 5 - Role of Investment Funds such as Acumen, Example in India

In 2008, Acumen Fund made a US$1.26 million equity investment in New Delhi-based SBA Hydro and Renewable Energy Ltd (SHREY). SHREY's goal is to provide hydroelectric power to villages in the Himalayan Belt of northern India where, despite grid access, electricity supply is unreliable. Through design innovation in micro-turbines and generators, SHREY has developed a number of new turbine designs appropriate for the India micro-hydro context—customised to reduce cost and raise output efficiency.

Acumen Fund is a non-profit global venture fund that uses entrepreneurial approaches to solve the problems of global poverty. Its aim is to help build financially sustainable and scalable organisations that deliver affordable critical goods and services that improve the lives of the poor. Acumen's investment has resulted in the provision of reliable electricity to more than 6,000 households, representing more than 30,000 people living in rural India.

Access to power can lead to improvements in education, local enterprise and industrial growth, higher quality of life through access to information and increased productivity, and improved local infrastructure by customised schools, health facilities, and community institutions. Additionally, as a renewable energy source, micro-hydro power will offset polluting and diminishing fossil fuels. Preliminary calculations estimate that SHREY's 1MW of hydro power correlates to an emission reduction of approximately 4,000 tonnes of carbon annually.

In Depth 6 - Role of Foundations such as FRES (Nuon), Example in Burkina Faso

Foundation Rural Energy Services (FRES) have established commercial electricity company Yeelen Ba in Burkina Faso. Yeelen Ba will provide 3,000 households and small businesses with energy services in the Kénédougou province by 2012.

Foundation Rural Energy Services is a non-profit foundation, founded by Dutch electricity company Nuon in 2004. FRES provides clean energy to families that reside in the rural areas of developing nations. The foundation does this by setting up electricity companies that generate clean electricity from solar power. FRES aims to establish new companies to provide approximately one million people with electricity in a professional, sustainable, environmentally safe and most of all healthy manner.

FRES relies on commercial investors as well as private donations.

Yeelen Ba's first clients were connected in July 2009. By 2012, Yeelen Ba will open 8 energy stores, hire and train the staff for the headquarters and for the energy stores, organise marketing and sales campaigns.

In Depth 7 - Role of Private Companies such as Scatec Solar, example in India

The Rampura Community Solar Power Plant in the state of Uttar Pradesh was inaugurated in January 2009. Installed at a cost of US$67,500, the 8.7kW solar PV power plant provides electricity to all 69 houses in the village. The power is distributed through a local mini-grid.

The project was developed and funded by Scatec Solar of Norway with a view to showcase the new opportunities posed by solar energy and gain first-hand experience about design, construction and operation of stand-alone solar plants in the village. Non-profit organisation Development Alternatives provided on-the-ground administration and facilitation. The long-term aim is to use the pilot project to build a working model, which will enable a large-scale roll-out across India and other similar regions of the world.

Power is used for lighting, fans and entertainment/educational purposes (TV, radio, Personal Computer etc). The plant is sized so that the villagers may also utilise the electricity to improve existing, or establish new, income generating activities (flour mill, water pumping and distribution, sewing machines, cash crop drying etc).

The villagers are required to pay for the electricity and internal wiring for their homes. The revenues generated will cover operation and maintenance costs, as well as the replacement of batteries and other components. The electricity tariffs have been set by considering the local willingness to pay, based on what the villagers have had to pay for conventional sources of energy, such as kerosene and diesel. A Village Energy Committee has been formed with local people's representatives plus experts actively involved in the development of the area. This committee plans, implements, monitors and controls the project activities including penalties and disconnection and handles bill preparation and collection.

Until now, the only source of lighting in the villages has been kerosene lights. The arrival of electricity has significantly improved health conditions, especially for women and children, and has enabled school children to study in the evenings.

In Depth 8 - Role of Multilateral Aid Funds such as SIDA, Example in Tanzania

Less than two per cent of Tanzania's rural population has access to electricity. With support from the Swedish International Development Cooperation Agency (SIDA), Tanzania is working to connect rural areas to the national electricity network. The result is both a higher standard of living and a reduction in carbon dioxide emissions.

In 2008, the Swedish government decided that SIDA would invest US$73 million to electrify the Iringa and Ruvuma regions of southwest Tanzania. These investments will provide electricity to 1.5 million people.

SIDA demands that the work involved in the electrification process takes the environment and human rights into account. SIDA has therefore also been supporting Tanzania's electricity company TANESCO in planning and having a dialogue with the inhabitants in the areas that are receiving electricity.

More than half of the electricity that is produced in Tanzania consists of hydropower, the remainder comes from natural gas and other fossil fuels. In rural areas that cannot be reached by the national network, imported fossil fuels are transported in tankers to power diesel-electric generating sets. The investments are reducing carbon-dioxide emissions in Tanzania as hydropower and natural gas replace diesel, which is driven out to rural power plants and diesel-electric generating sets.

In Depth 9 – Role of CER Credits, Example of Project by DESI Power in India

Carbon credits are a key component of national and international attempts to mitigate the growth in concentrations of greenhouse gases (GHGs). If the alternative is to use fossil fuels, renewable energy projects reduce GHG emissions and therefore can generate carbon credits. These carbon credits can be used as an additional source of project finance.

The most relevant type of carbon credits for Community Power projects are Certified Emission Reductions (CERs), issued by the Clean Development Mechanism (CDM) Executive Board for emission reductions achieved by CDM projects and verified by a Designated Operational Entity (DOE) under the rules of the Kyoto Protocol. The process of applying for CERs is somewhat cumbersome and expensive, and will only be attractive if many Community Power projects are combined. A process already exists under the CDM whereby small scale projects can be bundled together. This process has already been pioneered by DESI Power in India; the documents they have filed under the CDM are publicly available and can be found on the UNFCCC website[45].

Where there are insufficient projects to be bundled together, voluntary carbon credit projects represent an alternative and viable solution. Voluntary credits have lower value than CERs, and are harder to sell forward to help with project finance, but the application process is cheaper and less complex. Different voluntary standards exist, with the best known including the Voluntary Carbon Standard and the Gold Standard.

In Depth 10 – Role of Mission Driven Investors such as E+Co, Example in Tanzania

Mona Mwanza is an electronics store in Mwanza, Tanzania in which E+Co invested US$50,000 of debt in 2002 to grow their business to include the sale of solar PV technology. This was after having worked with the company extensively to formulate their expansion plans into the clean energy sector. Within a year, the company had expanded their solar work considerably, and E+Co invested another US$100,000. With increased access to capital, the company was able to import solar panels in bulk, thereby dropping the price and growing the business more quickly. As the second largest city in Tanzania, Mwanza has a surprisingly low 5.9% electrification rate with no plans for national grid extension. After only two short years, Mona was already serving thousands of customers with electricity.

Shortly thereafter, the entrepreneur, Mohamed Parpia, spun out a separate company called Zara Solar to work exclusively on solar PV distribution, and E+Co invested US$200,000 of debt in that company. Zara now serves over 20,000 households with clean, reliable solar electricity. In 2007, the company won the International Ashden Award for Sustainable Energy presented by former U.S. Vice President Al Gore.

E+Co is an investor in small and growing clean energy enterprises in Africa, Asia and Latin America. They are a mission driven investor, investing for the dual purpose of positively impacting climate change and alleviating poverty. They provide enterprise development services and capital in markets where neither is available to the small and growing enterprises they support. Their investments are currently in the range of US$25,000-US$1.3 million. "Serial investments" such as the one in Mona Mwanza and Zara Solar, in which smaller loans are made based on performance benchmarks that better match a company's growth curve, are a critical part of their model. This approach mitigates risk in otherwise high risk markets, while aligning incentives for company success and growth.

In Depth 11 - Electricity Act 2003, India

The Electricity Act 2003 consolidates the laws relating to generation, transmission and distribution, trading and use of electricity and provides measures conducive to development of the India electricity industry and providing power for all. The Act is articulated along three mains axes; it (1) supports the liberalisation of the market, (2) removes subsidies and pricing issues and (3) improves permitting and licensing conditions in the Indian energy sector:

Liberalisation of the Market

- development of a liberal framework for power development and competitive environment

- facilitation of private investment
- de-licensing of generation and transmission
- enablement of multiple licensing in distribution
- support of renewable energy development.

Elimination of Subsidies and Pricing Issues
- gradual phasing out of cross subsidies
- creation of Regulatory Commissions with retail tariffs to be determined by regulatory commissions.

Improvement of Permitting and Licensing Conditions
- making trading a distinct activity permitted with licensing
- mandating open access in distribution to be allowed by State Electricity Regulatory Commissions (SERCs) in phases
- mandating open access for transmission from the outset
- forcing states to restructure electricity boards.

Finally, the Act also provides stringent provisions for controlling theft of electricity and focuses on revenue recovery in cases of unauthorised use of electricity.

In Depth 12 - Telecoms Infrastructure Sharing, India

Telecoms infrastructure sharing has been promoted through:
- Project MOST (Mobile Operators Shared Towers) - launched by the USO Fund in 2006 to provide subsidy support for setting up and managing 7440 base stations in 500 districts spread over 27 states for provision of mobile services in the specified rural and remote areas, where there is no existing fixed wireless or mobile coverage. The infrastructure created is shared by three service providers for provision of mobile services. Mobile services from these towers were launched in a phased manner by end of 2008.
- Active BTS component sharing facilitated by Ministry of Communications & Information Technology. Active infrastructure sharing is limited to antenna, feeder cable, Node B, Radio Access Network ("RAN") and transmission system only. Sharing of the allocated spectrum is not permitted
- Universal Service Obligation (USO) funds for investigating the feasibility of renewable energy powered base stations. Base stations must be shared by at least 3 operators to qualify for subsidies from USO funds.

In Depth 13 - RGGVY Rural Electrification Scheme, India

The scheme makes provision for providing electricity to families below the poverty line for free. Under the scheme, a village is said to be "electrified" if 10 per cent or more of its households have an electricity connection. It was launched in April 2005 by merging all ongoing rural electrification schemes and allocating funding for US$3.8 billion. Grants from the RGGVY are sometimes combined with loans from the Rural Electrification Corporation (REC) to cover 100% of the capital cost of the project. Typical projects covered by the RGGVY programme include:
- Rural Electricity Distribution Backbone (REDB) - Provision of 33/11 KV (or 66/11 KV) sub-stations of adequate capacity and lines in blocks where these do not exist
- Creation of Village Electrification Infrastructure (VEI)
- Decentralised Distributed Generation (DDG) and Supply

In Depth 14 - Renewable Investment Scheme, Department of Telecom, India

The Indian Department of Telecom has called for expressions of interest from infrastructure providers, to establish the technical feasibility and financial viability for solar/solar-wind hybrid renewable energy systems in shared mobile infrastructure in rural/remote areas[46]. Pilot projects presented typically involve the infrastructure provider providing the renewable energy infrastructure with the assistance of a renewable energy vendor. The subsidy support from the government covers up 75% of the project cost.

At this stage, the scheme leans heavily in favour of solar power solutions, with no current provisions for wind power-only deployments. The scheme is currently only open to infrastructure providers and not to operators and grant conditions require that sites actually are shared, the infrastructure provider must get consent from three operators sharing the site to be eligible for the subsidy. Each pilot project has twelve weeks to complete installation from the date it is signed, and must run for twelve months before complete subsidy support is released.

In Depth 15 – Energy for Rural Transformation Project (ERT), Uganda

The project has three components:

- Rural energy infrastructure: financing of grid extension, independent distribution systems, small scale renewable energy generation plant and related technical assistance and training. Cost-shared assistance to private sponsors seeking financial closure on rural energy investments
- Rural ICT: financing of internet broadband extension to rural areas, new community information centres, cell phone charging stations for existing community information centres, and computer equipment for schools and health clinics
- Energy development: financing of solar PV energy packages for rural schools, health clinics, and water facilities, and includes related technical assistance, training, and operating costs.

Key features of ERT of relevance to Community Power are (1) its Business Development Services, Energy for Rural Transformation (BUDS-ERT) – a grant scheme that provides financial support and advisory services to the private sector firms, community based organisations, and other private entities in the energy and ICT business, and (2) the Energy for rural transformation Refinance Fund (ERTRF) - a refinancing facility funded by World Bank. It is managed by Bank of Uganda and represents government's intervention in promoting the financing of renewable energy projects. The ERTRF amounts to nearly US$15.3 million.

3. Community Power Research: List of Interviewees

Mobile Network Operators
Axis Telecom (Indonesia)
Bharti Airtel (India)
Grameenphone (Bangladesh)
Idea Cellular (India)
MTN (South Africa)
MTN Group
Orange Group
Qatar Telecom
Safaricom (Kenya)
Telenor Group
Vodacom Tanzania
Zain Group
Zain Tanzania
Zantel (Etisalat Group, Tanzania)

Tower Companies
Bharti Infratel (India)
GTL Infrastructure (India)
Indus Towers (India)
Quippo Telecom Infrastructure (India)

Vendors / Rural Electrification Organisations
ACME Telepower (India)
Alcatel Lucent
Altobridge (UK/South East Asia)
Association for Renewable Energy (Belgium/Africa)
Association of Biogas Contractors (Kenya)
Cleanstar (India)
DESI Power (India)
Ericsson
GreenX (South Africa)
GVEP International
Husk Power Systems (India)
Nokia Siemens Networks
Scatec Solar (Norway)
Tesuco (South Africa)
The Wind Factory (Netherlands/Africa)
Winafrique (Kenya)

International Development Organisations
Acumen Fund
E+Co
International Finance Corporation
Rockefeller Foundation
Shell Foundation
UK Department for International Development
World Bank/IFC Lighting Africa

Regulators / Others
Carbon Trust
Communications Commission of Kenya
Ministry of New and Renewable Energy (Govt of India)
Tanzania Communications Regulatory Authority
The Climate Group
The Energy Research Institute (India)
USO Fund India
Voluntary Carbon Standards Organisation

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January 2010