Green Power for Mobile

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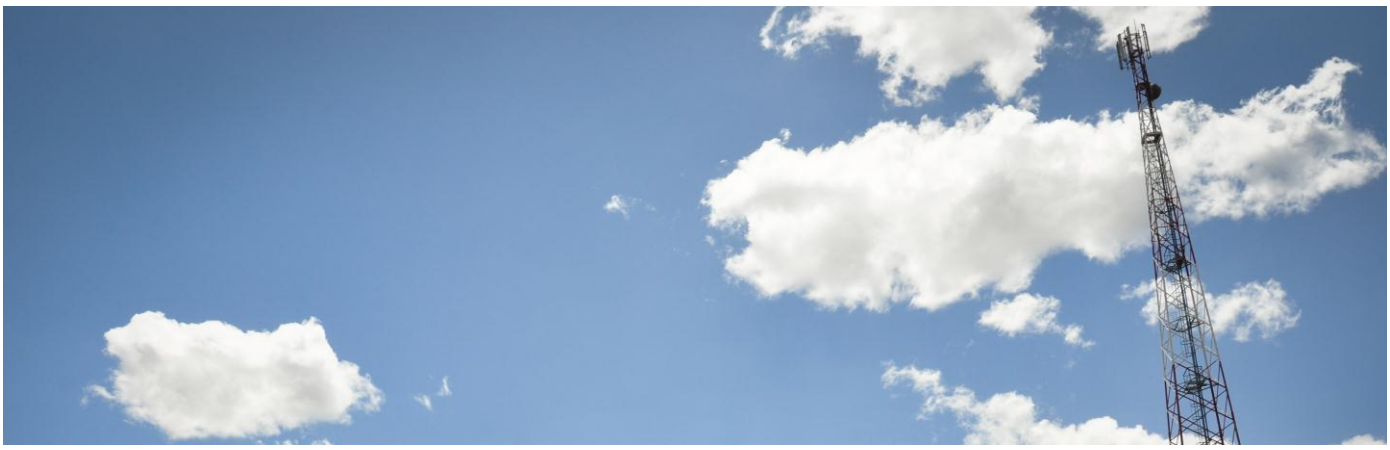


Telekom Networks Malawi (TNM) Ltd. – Malawi – Feasibility Study

Malawi, with a population of about 15 million[1], is one of the most densely populated countries in the sub-Saharan Africa. Malawi is a land locked country connected to the ports through Mozambique and shares its borders with Zambia, Mozambique and Tanzania.

Introduction

Malawi is a tropical country with rains from November to April and with little or no rains for rest of the year. It is home for the third largest lake in Africa, Malawi Lake occupying about 20% of the total area lying in the troughs of the Great Rift Valley traversing the country north to south. The altitudes range from 600 to 1600 meters above sea level, rising to over 2000 meters at Zomba Plateau and Nyika Uplands, and over 3000 meters in Mulanje Mountains[2].

Malawi's economy predominantly depends on agricultural produce and productivity, employing majority of the country's workforce. Agriculture contributes about 35% to the GDP, and more than 80% of the export revenues with tobacco, tea and sugar being major export commodities[3]. The agriculture sector faces key challenges in productivity and cost efficiency due to lack of infrastructural and policy support. As a land locked country, Malawi faces major infrastructure challenges in terms of transport and freight which contribute significantly to the cost of imports and exports. Malawi faces acute problems with shortages in foreign exchange reserves resulting in fuel shortages and higher cost of imports. Malawi's conservative investment policies, trade barriers and an unsupportive investment environment hindering foreign investment, remain major obstacles to growth and development.

[1] http://en.wikipedia.org/wiki/Malawi
[2] http://en.wikipedia.org/wiki/Malawi
[3] http://en.wikipedia.org/wiki/Malawi

Telekom Networks Malawi (TNM)

TNM is the second largest mobile operator in Malawi with a subscriber base of 1.6 million and a market share of over 42%.[4] A pioneer in offering new services, TNM became the first mobile operator in Malawi to launch and offer 3G services including video calling, video and music streaming, and mobile broadband access. TNM is the trusted operator in corporate customer segment with a loyal customer base contributing to a market share of over 67% in the segment.[5]

TNM has been in the forefront in providing access to mobile services to the rural population and has seen the increase in penetration level from 8% in 2007 to 22% in 2010.[5] With a network of 380 base station sites in the access network, TNM covers about 74% of Malawi and over 85% of its population.[5]

Telekom Networks Malawi (TNM) started its operations in 1995 as a joint venture between Telekom Malaysia Berhad (TMB) and the then government owned Malawi Postal and Telecommunications Corporation (MPTC). MPTC is later split into two entities – postal (MPC) and telecommunications (MTL). Currently, TNM is the wholly owned Malawian public limited entity with major shareholding by MTL, Livingstone Holdings Telekom Ltd, Press Corporation Ltd and Old Mutual.[5]

Malawi's Infrastructure & Challenges

Electricity and transport infrastructure remain the biggest challenges to the economic development of Malawi.

Poor roads, underdeveloped freight and rail access, limited air links and poor access to ports represent Malawi's transport infrastructure. Development of cost effective and reliable transport infrastructure will be a key to bring in productivity and competitiveness in economic activities.

Power infrastructure of Malawi

The power supply situation in Malawi has limitation in terms smaller base of installed production capacity followed by poor transmission and distribution infrastructure. Power sector needs significant improvements in reliability and access, in order to boost and sustain the economy of the country.

95% of the electricity supply in Malawi is contributed from hydro power generation plants developed and operated by Electricity Supply Corporation of Malawi (ESCOM), a public utility responsible for generation, transmission and distribution of electricity in Malawi. ESCOM has a total installed generation capacity of 300 MW of which hydro accounts for 282.5 MW.[6]

Malawi has one of the lowest electrification rates in the world with only 7% of the country having access to electricity. Only 1% of the rural households are electrified while around 25% of the urban households have access to electricity.[7]

Malawi's Energy Resources

Malawi's energy balance is dominated by biomass accounting for about 97% of total primary energy supply. Malawi has no natural oil and gas resources, and imports almost its entire fuel requirement. Coal production meets only 25% of its total requirement.[7]

Telecoms and Power infrastructure

Power and transport sectors hold key contributions to the cost of telecom services as the telecom operations heavily dependent on the level of power and transportation infrastructure to run the network cost effectively.

Telecommunications sector in Malawi is dominated by four major players, two in mobile services and two focused on fixed line services. In the recent years, the mobile operators have expanded their network to reach and cover population across the whole country. Most

[4] TNM Annual Report 2011

[5] TNM Corporate profile – www.tnminvestor.com

[6] ESCOM Ltd – Corporate Profile (http://www.escommw.com/generation.php)

[7] REEEP Policy Database (http://www.reeep.org/index.php?id=9353&text=policy-database&special=viewitem&cid=94)

of the network expansion falls in the rural, off-grid location with no or limited access to electricity. This poses many infrastructure challenges to the operators and affects their operations in terms of higher operational costs and higher costs per user served.

Another challenge for mobile operators in Malawi is to connect the off-grid sites to nearby grid location. The costs of grid extension to off-grid sites is do not present a viable business case. Due to unreliable grid access and lack of grid infrastructure, the mobile operators have to rely heavily on diesel generators to power their network.

Operator Challenges

TNM faces a major challenge to power a network of 380 exiting telecom base station sites. The current network consists of telecom sites deployed in both off-grid locations and on-grid locations. The on-grid sites have reasonable electricity supply from ESCOM except for an average of 4 hours of power outage per day due to the scheduled load shedding from the utility. However, the off-grid sites completely rely on diesel generators to power the equipment.

A major challenge for the operator is to procure and store diesel for running the sites. In the recent times there have been acute fuel shortages in the country and the fuel prices have crossed US$ 2 per litre of diesel which puts a lot of burden on telecom operations and costs of energy provision to the network.

In addition to the cost of diesel to run the diesel generators, most of the off grid sites are in remote locations where accessibility is a challenge. This adds to the cost of running a diesel generator by increased logistics costs due to periodic refill of diesel.

Planning for energy provision to off grid and unreliable grid sites is very critical in meeting the demand for network expansion across the country. The challenges to power the network efficiently and cost effectively has necessitated the operator to take up comprehensive study to optimize the power requirement and to evaluate green power technologies as an alternative to power the network.

Challenges During Feasibility Study

A comprehensive green power feasibility analysis on the entire network of telecom sites will require extensive data about the network. In addition to the technical data on site configuration and power requirements, other specific details about each site including geography, accessibility, logistics and renewable energy resources is critical to the analysis.

Collection of data is one of the major challenges encountered during the feasibility study. TNM has its operations divided in four regions of the country which added complexity during the data collection phase as there was no centralized database for operational data. Data validation was also a challenge as there were deviations due to manual collection of data. The availability of supplier and pricing information, equipment specifications and other commercial information was another challenge faced during the feasibility study.

The conduct of site visits to gather field level information was another challenge for the feasibility study. Due to the prevailing fuel shortages across Malawi, it was challenging to plan for sites visits across the four regions where TNM has its operations. Representative sites have been chosen for sites visits to get an overall understanding of the entire network.

Feasibility Study and Approach

The feasibility study has carried out according to GSMA Green Power for Mobile methodology involving detailed data collection, data analysis, model design, business case development, implementation prioritization and financial analysis followed by recommendations.

Network & Data Analysis

Complete data on base station sites is collected for the active network of sites and validated through several iterations. TNM has a network of total 380 base station sites and transmission sites across the country. Network data for 365 sites was collected and shared for analysis, of which 300 sites are on-grid sites and remaining 65 sites are off-grid.

After overall network analysis, 65 off-grid sites are shortlisted for Green Power solutions. The on-grid sites are not considered for green power solutions as they do not present a viable business case. The on-grid sites have an average daily power outage of 3.45 hours based on scheduled load shedding from ESCOM. Generic recommendations have been proposed for the on-grid sites to completely remove the dependence on diesel generators.

Air-conditioners remain major load at indoor (shelter) sites. The total operating load of the entire network is 1,175 kW out of which 721 kW (~61%) is air-conditioner load. There are a total of 319 indoor sites (~87%) with an average site load of 3.47 kW, air-conditioners amounting to an average load of 2.26 kW per site.

The diesel generators are run for 1,864 hours every day to power the entire network including on-grid and off-grid sites. This accounts for a daily diesel OPEX of over US$ 10,000 to power the entire network.

Table 1: Network Analysis

<table>
<tr><th rowspan="2">Basic Analysis</th><th colspan="2">Deep Analysis</th><th rowspan="2">Observation</th><th rowspan="2">Key note</th></tr>
<tr><th>Off Grid</th><th>On Grid</th></tr>
<tr><td rowspan="3">- Total 365 sites.

- 65 off-grid, 300 on-grid

- 65 off-grid sites are considered for Green Power solutions

- 319 (87%) of the sites are indoor sites</td><td>- Average telecoms load of 1.16 kW, while overall average site load is 3.13 kW

- 57% of load is air-conditioner load at indoor sites

- 53 indoor sites and 12 outdoor sites

- Daily DG run of 834 hours</td><td>- Average telecoms load of 1.38 kW, while overall average site load is 3.24 kW

- 62% of load is air-conditioner load at indoor sites

- 266 indoor sites and 34 outdoor sites

- Daily DG run of 1030 hours</td><td rowspan="3">- Diesel Generator runs for 1864 hours everyday

- 61% of the power consumption is by air-conditioners at indoor sites</td><td rowspan="3">- Daily OPEX to run Diesel Generator is US$ 10,300

- Daily CO_2 emission is 12.33 Tonnes</td></tr>
<tr><td colspan="2">- Average load per indoor site is 3.47 kW, while for outdoor site the average load is 1.47 kW</td></tr>
</table>

Model Design & Solutions

Based on the overall network data analysis, GPM has considered the 65 off-grid sites for renewable power solution design. A total of 9 design models covering 65 sites are evaluated and dimensioned for renewable energy solutions.

Design Modelling Approach:

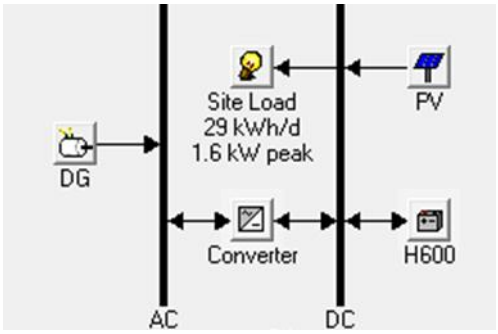
- 5 Solar designs (3 indoor and 2 outdoor) are modelled and evaluated for financial feasibility
- 2 Wind-solar hybrid design models developed and evaluated against solar models
- Indoor to outdoor site up-gradation is considered for green power solution design and evaluation
    - 2 Solar designs with indoor to outdoor upgrade scenario are modelled for evaluation and comparison with corresponding Solar as well as Wind-solar hybrid models

After careful evaluation of the design models for technical and financial feasibility, a final list of 5 design models covering all the 65 off-grid sites are proposed.

Every design model is prepared for optimum technical solution and proposed based on best financial results for optimum operations. Each model provides technical dimensions for all the equipment proposed as part of the green power solution.

An example of a site design model is presented below.

Figure 1 - Site design sample



Business Cases & Financial Analysis

GPM has developed business cases for each model and evaluated for financial feasibility considering a 10 year business plan. The business cases are prepared considering actual market data and rates provided by the operator and vendors. Each business case demonstrates an overview of CAPEX, OPEX, Savings and investment metrics such as NPV and ROI.

Prioritization & Investment Plan

After careful analysis, solution design and financial evaluation, the sites are grouped into implementation priorities in order deploy the proposed solutions in a phased manner. Based on site characteristics, investment requirements and financial returns, GPM has proposed 3 implementation priorities for deploying the proposed renewable power solutions. Every priority is supported with investment plan and financial analysis.

Results and Recommendations

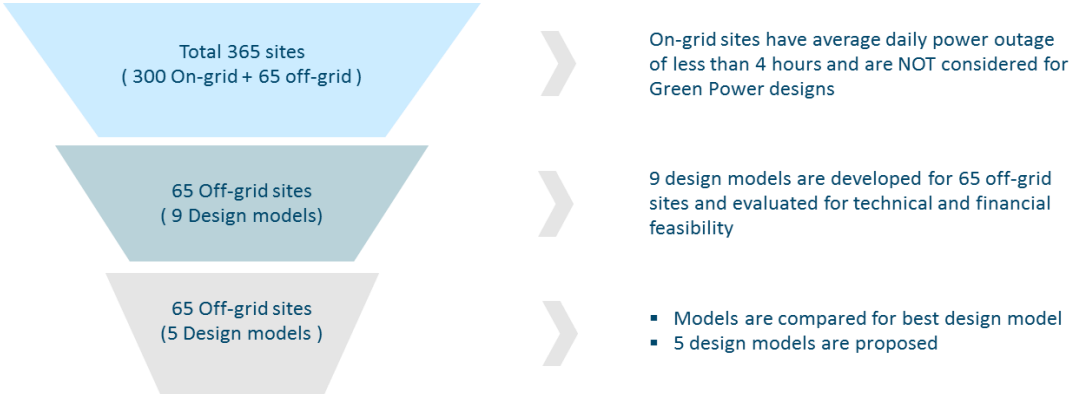
The recommendations of GPM fall in to two categories,

- Energy solution recommendations
- Energy efficiency recommendations

The recommendations for energy solutions is based on comprehensive technical analysis, design and evaluation of the sites through GPM feasibility study, while the energy efficiency recommendations are based on qualitative analysis through site surveys and discussions with the operations team at TNM.

Energy Solution Recommendations

GPM, after a thorough analysis of the design models and business cases, has proposed renewable energy solutions for 65 off-grid sites. Out of the 9 designs considered, 7 are solar models (including 2 solar models with indoor to outdoor site upgrade) and 2 are wind-solar hybrid models. The 5 design models finally proposed are solar power models.



The energy solutions are designed based on precise site load characteristics and are optimized for best financial indicators reducing the cost of energy and dependence on diesel generators for powering the network. The technical parameters for deployment are also considered while recommending the energy solutions especially the space requirement for solar photovoltaic installations.

Solution dimensions

Each design proposes optimum solution dimension and equipment sizes to minimize the cost of energy produced and maximum utilization of the energy generated. The solution dimensioning for the final proposed models are presented below.

Table 2: Solution and Equipment dimensions

		Proposed Solution					Renewable Indicators				
No. of Sites Proposed	Model	PV	Controller	Battery	DG	Land Req. (Sq.m)	PV	DG	Battery Autonomy (Hrs)	Green Power (kWh/yr)	Excess electricity (%)
5	OD1	6.8 kW	150 A	2 x 600Ah	12.5 KVA	48.96	92 %	8%	33.7	11,103	5.52%
7	OD2	8 kW	150 A	2 x 600Ah	12.5 KVA	57.6	83 %	17 %	27	12,435	4.45%
35	ID1	9.6 kW	200 A	1 x 1000Ah	12.5 KVA	69.12	80 %	20 %	17.7	15,778	7.97%
2	Upg_1	6.8 kW	150 A	2 x 600Ah	12.5 KVA	48.96	92 %	8%	33.7	11,103	5.52%
16	Upg_2	8 kW	150 A	2 x 600Ah	12.5 KVA	57.6	83 %	17 %	27	12,435	4.45%

Based on the proposed equipment dimensions, each design model is evaluated for commercial viability by developing business cases for each design model. The business case incorporates all the commercial parameters associated with the solution including CAPEX, OPEX and other commercial items. Based on the technical parameters and commercial inputs, GPM has prepared the financial model over a 10 year planning period

and demonstrated the benefits as compared to the existing scenario. The business case and financial analysis provide an overview of CAPEX, OPEX, Savings and investment metrics such as NPV and ROI for each design model.

Green Power Solution & Excess Electricity

Green power solutions for off-grid locations can be designed to produce excess electricity which can be provided to the local community for small needs such as charging the handsets, batteries and lights.

The excess electricity shown in Table 2 is not continuously available for the community; however a modified design will provide continuous excess electricity for planned community power activities. The Community Power from Mobile (CPM) work stream at GSMA works with the operators to design, develop and promote community power business models utilizing the excess electricity produced at each site.

The operators can benefit from increase in ARPU due to increased minutes of usage and reduced OPEX per user due to increased subscriptions.

Implementation Priorities

Based on the technical solution and financial analysis the sites have been grouped into implementation priorities to better plan for deploying the green power recommendations. 16 of the total 65 off-grid sites are in the process of grid connection and are excluded from implementation prioritization. The remaining 49 off-grid sites are grouped into three implementation priorities. Priorities are assigned based on site importance, site characteristics, CAPEX, ROI and OPEX saving for each site. Off grid sites, critical sites and sites with better financial indicators are given higher priority for implementation.

Table 3: Priority summary

Priority	Number of Sites	Energy contribution (Average)		Battery Autonomy (Avg. Hrs)	DG run per year (Avg. Hrs)	Diesel Savings (L/yr)	Green Power generated (kWh/yr)	CO_2 Emission Reduction (tonnes/yr)	Payback Period
		Solar	DG						(yr)
1	14	85%	15%	24.7	283	172,623	190,831	212.8	1.81
2	27	80%	20%	19.1	402	292,617	412,634	372.4	2.28
3	8	84%	16%	27.8	225	84,921	98,148	99	2.92
	49					**550,160**	**701,613**	**684.2**	**2.25**

Investment plan

Financial analysis for each priority is carried out to give a clear understanding of investments in proposed solutions as well as the associated financial and environmental benefits of implementing the proposed green power solutions. The calculations are based on a 10 year project lifespan.

The summary of the investments, performance indicators and financial returns are given below for all the priority groups.

Table 4: Priority wise Investment summary

Priority	No. of Sites	Total CAPEX (US $)	Total OPEX (US $/yr)	OPEX Saving (US $/yr)	Payback Period (yr)	ROI	IRR	NPV (US $)	CO_2 Emission Reduction (tonnes/yr)
1	14	930,425	31,308	524,501	1.81	58%	54%	1,385,578	212.8
2	27	2,090,785	77,134	918,219	2.28	44%	42%	1,967,090	372.4
3	8	780,260	17,765	267,250	2.92	35%	34%	443,921	99.0
Overall	**49**	**3,801,470**	**126,207**	**1,709,970**	**2.25**	**46.5%**	**43.8%**	**3,796,589**	**684.2**

Investment Alternatives

The operator is presented with various models of funding the implementation of green power solutions on their network.

CAPEX based model

In this approach, the operator is responsible for mobilizing the investment required for implementing the green power solutions. One option for the operator is to budget entire investment from own reserves or investment pumped in from its investors. Another option is to explore funding alternatives with financial institutions through various financial instruments including debt financing.

GPM provides access to various funding alternatives for green power implementation through IFC (International Finance Corporation). IFC has come up with various financial instruments such as debt, quasi-equity etc. to finance and promote green power implementations.

Outsourced model or OPEX based model

The outsourced model or OPEX based model provides the operators with an alternative to deploy green power solutions on their network. In this approach the operator outsources the deployment of green power solutions to third party energy service companies (ESCOs). The ESCOs will take the investment responsibility and provide the operator with energy services based on a fixed cost basis or a variable rate based on kWh consumed.

GPM can assist the operator in developing an outsourced energy model by bringing in and connecting with third party energy service providers.

Energy Efficiency Recommendations

For overall energy optimization, GPM came-up with a list of recommendations which could help TNM, Malawi reduce their energy requirement at every site.

Generic recommendations to optimize and reduce passive load (thermal and lighting load) -

- Use separate battery cabinet with cooler for deploying batteries
- Install VDT(Voltage Dependent Timer)/intelligent controller to manage battery and DG operation
- Use a battery cooler for all sites. It may increase battery life up to 50%.
- Use energy saving light for all sites
- Recommended to consider replacing AC air-conditioner for all indoor sites with low power alternative cooling systems
- Recommended for use of Free Cooling Units (FCU) or DC Aircon for Shelter/BTS-room environment control in combination with a separate battery cabinet with cooler for batteries
- To reduce the other thermal load by keeping only the telecom equipment in BTS-room

Generic recommendations to optimize active load at base station sites

- Smart control of TRX on/off based on traffic and time of day
- Purchase outdoor BTS for upcoming deployments
- Consider upgrading existing indoor equipment to low power outdoor BTS equipment

Implementation of these recommendations would enable TNM to improve energy efficiency of the network, reduce OPEX up to 25-40% and remove dependency on diesel generators to power the network.

In addition to the generic recommendations to improve overall energy efficiency of the network, GPM also proposed some specific recommendations to be implemented on-grid sites which are not considered green power solution design.

Specific recommendations for on-grid sites

- 89% of on-grid sites are indoor sites and 55% of power requirement at indoor sites is for running AC air-conditioners
    - Save energy bill by deploying FCU or DC Aircon for indoor sites
- Implement Grid + Battery hybrid at all on-grid sites
    - Save diesel consumption of 2500 L per day
- Extend battery capacity to 800 Ah for low power sites and 1500 Ah for high power sites
- Use separate battery cabinet with cooler for Batteries
    - Improve battery life by approximately 50%

Summary

After a comprehensive Green Power Feasibility Study, GPM concluded that:

Green Power Solution Recommended for:	49 Off-grid Sites
No Green Power Recommendation for:	300 On-grid and 16 Off-grid Sites
Recommend Battery Cycling for:	All the On-grid sites
A list of generic recommendations those can save up to 25-40% of energy OPEX.	

The investment parameters and financial metrics for implementing the green power recommendations are provided below.

CAPEX requirement for Green Power Solution deployment	US$ 3.8 million
Current Energy OPEX for all sites	US$ 1.84 million/yr
Energy OPEX post Green Power deployment	US$ 0.12 million/yr
OPEX Savings by implementing Green Power Solutions	US$ 1.71 million/yr
Average Pay back period	2.25 years
Average NPV	US$ 77,481
Average ROI	46.5%
Reduction in CO2 emissions	**684.2 Tons/yr**

GSMA Green Power for Mobile Programme

Promoting Green Power to Extend Mobile beyond the Grid

An estimated 1.6 billion people live without electricity. An additional 1 billion people live in areas with unreliable access to power. In order to expand into areas without regular electricity, mobile networks have primarily used diesel generators for power. However, as diesel prices rise and mobile network infrastructure is built in increasingly inaccessible regions, mobile operators need a viable alternative to diesel, such as solar and wind power. Recent technological improvements and cost reductions in green power solutions have made this alternative more commercially attractive. Coupled with the environmental benefits of reduced diesel use and subsequent emissions, green power solutions provide a promising opportunity for operators.

The GSMA Green Power for Mobile programme has set the goal of helping the mobile industry use renewable energy sources, such as solar, wind, or sustainable biofuels, to power 118,000 new and existing off-grid base stations in developing countries by 2012. Achieving that target would save up to 2.5 billion litres of diesel per annum and cut annual carbon emissions by up to 6.8 million tonnes.

The Green Power for Networks work stream within the Green Power for Mobile programme focuses on aiding the mobile industry to deploy solar, wind, or sustainable biofuels technologies to new and existing off-grid base stations in developing countries. The Green Power for Networks work stream supports the mobile industry in this initiative by providing:
- Network Feasibility Studies: Complete network assessments on technical and financial viability of renewable energy for BTS sites.

Aiding network operators to deploy renewable energy, GPM will be promoting the expansion of mobile networks into regions currently lacking coverage (to bring coverage to the unconnected) and the systematic reduction of reliance on diesel consumption by operators.

Figure 3 – Project Locations and Operator Partners:

Community Power:

Community Power aims to utilize the excess power created by base stations, by distributing it into the local community. At a minimum, operators can provide excess power to the community for small needs such as charging up mobile handsets, large household batteries and rechargeable lanterns. At a maximum, the consistent power requirement of a mobile base station provides a stable demand for a bigger investment by a third party company in a village energy system, powering the base station as well as local homes and businesses. This is currently being investigated by the GPM team in India and East Africa with the hope of extending further into the developing world upon success.

GSMA Contacts

If operators are interested in finding out more about this service or the GPM programme please enquire at the contact information given below:

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http://www.gsma.com/Green-Power-for-Mobile/

About the GSM Association

The GSMA represents the interests of mobile operators worldwide. Spanning 220 countries, the GSMA unites nearly 800 of the world's mobile operators, as well as more than 200 companies in the broader mobile ecosystem, including handset makers, software companies, equipment providers, Internet companies, and media and entertainment organisations. The GSMA also produces industry-leading events such as the Mobile World Congress and Mobile Asia Congress.

About the Development Fund Serving the underserved through mobile

The GSMA Development Fund brings together our mobile operator members, the wider mobile industry and the development community to drive commercial mobile services for underserved people in emerging markets. We identify opportunities for social, economic impact and stimulate the development of scalable, life-enhancing mobile services.

For more information on the GSMA's Green Power for Mobile, please email greenpower@gsm.org

GSMA Development Fund