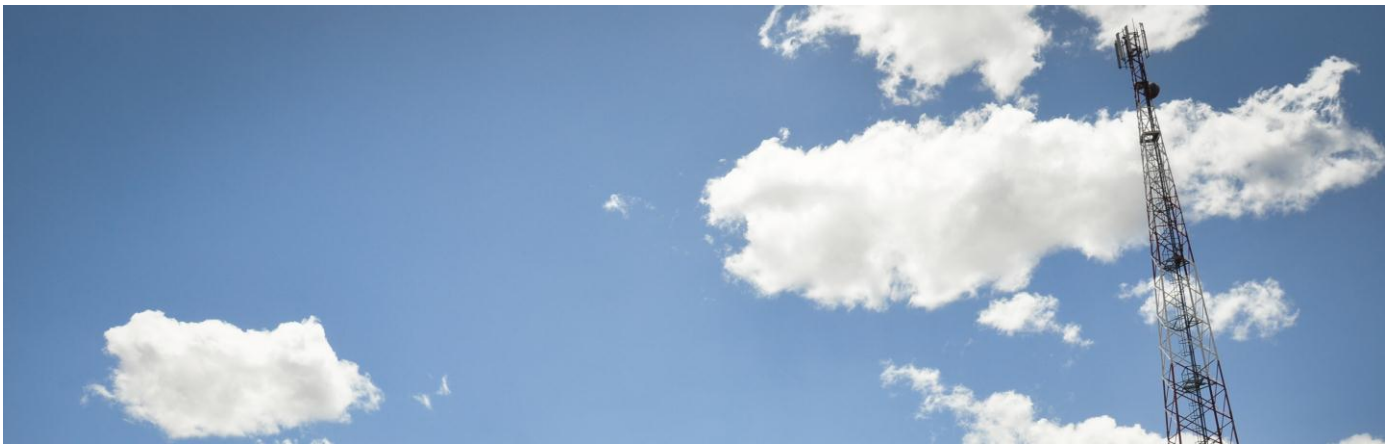
IFC International Finance Corporation World Bank Group

GSMA Green Power for Mobile

In partnership with the Netherlands



# Geocell – Georgia – Feasibility Study

Georgia falls in the Caucasus region of Eurasia and has varied landscape characterised by mountainous regions and valleys. Located in the east of Black sea, Georgia shares its boundaries with Russia in the north, Azerbaijan in the southeast and Turkey and Armenia in the south. Georgia's climate is very diverse ranging from humid subtropical to continental climate conditions. The climate conditions vary by distance from the Black Sea and by altitude. Altitudes above 2000 meters often experience frost conditions even during summer season.[1]

## Introduction

### Background

Tbilisi is Georgia's capital and largest city. Georgia's area is 69,700 km2 (26,911 sq. mi) and has a population of over 4.5 million. The GDP per capita is US$5,600. The main economic activities of Georgia are characterised by cultivation of agri-products such as grapes, citrus fruits and hazelnuts, mining of mineral resources and production of small scale alcoholic and non-alcoholic beverages. It imports most of its oil and natural gas products and has huge hydro power potential to meet the energy needs of the country. Georgian economy has recorded a growth rate of over 10% during 2006-07 and took a down turn during 2008 and 2009 due to conflicts with Russia and global financial crisis and then bounced back to present a growth rate of over 6% in 2010-11.[2]

### Operator: Geocell

Established in 1996, Geocell is the first GSM operator in Georgia operating on 900 MHz frequency and later on 1800 MHz frequency following the merger with GT Mobile; Georgia's 3rd operator to start GSM services, in 2001. Later in 2003, a controlling stake in Geocell is acquired by the TeliaSonera group. In 2006, Geocell acquired UMTS license to

[1] Wikipedia
[2] CIA World Fact Book

operate on 2100 MHz frequency and launched its 3G and associated services to its subscribers.

Geocell is the largest mobile operator in terms of subscriber numbers with a base of over 2 million as on Q1 2012.

## Overall Context

### Telecoms Industry - Georgia

The telecoms market in Georgia is dominated by 3 major national players lead by Geocell and followed by MagtiCom and Beeline respectively. Georgia has total subscriber connections of over 5 million as on Q1 2012. The year-on-year growth rate in connections is around 8.5% as on Q1 2012 at market penetration level of close to 120%.[3]

The other operators include AquaFon of MegaFon and A-Mobile operating in Abkhazia region of the country.

### Power Supply Scenario - Georgia

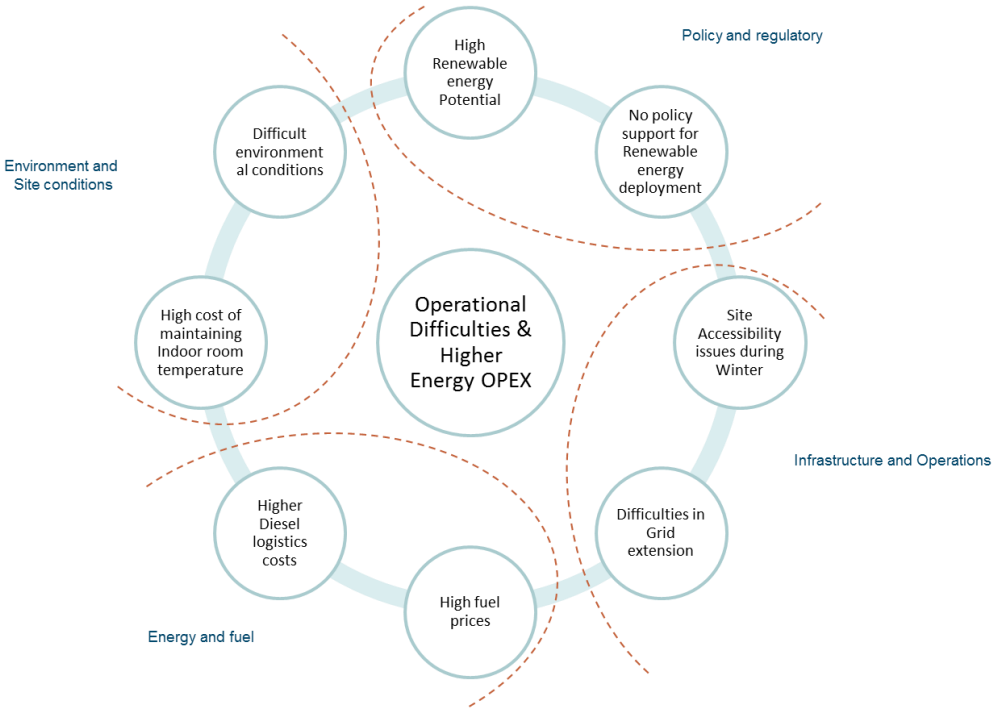
The grid power supply in Georgia is very reliable. Georgia has a huge hydro power potential to meet the energy needs of the country. Other renewable energy resources with good potential include wind, solar and biomass. However, Georgia requires major investments in terms extending the grid infrastructure reaching to the remote mountainous regions of the country.

Georgia's electricity production stands at 10 billion kWh mostly contributed by small and large scale hydro power generation plants whereas the consumption of electricity in Georgia stands at 9.3 billion kWh per year as on 2011.[4]

### Operator Challenges – Geocell

Geocell faces a major challenge in powering its 114 off-grid sites currently running on diesel generators. Majority of these sites have difficult accessibility, some of the mountain sites are extremely difficult to visit during winter period and present operational challenges in terms of powering and maintaining the site equipment. Grid connection costs are very high due to the costs involved in extending the grid infrastructure to most difficult locations where the sites are located.

The overall context in which Geocell operates is presented below.




[3] GSMA Wireless Intelligence
[4] CIA World Fact Book

## 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.

GPM has collected extensive data for all the sites in Geocell's network and data validation has performed for accurate analysis. GPM has faced challenges of obtaining market pricing information and supplier information for green power equipment and has collected pricing information from GPM's global vendor database and also, through the group operators.

Another key challenge during the feasibility study was to conduct field visits to the off-grid sites in mountain regions. GPM has chosen a representative list of sites to get an overall understanding of the site equipment and operating conditions.

## Feasibility Study & 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

Geocell has shared data for the entire network to carry out analysis and green power feasibility study. The data was collected extensively to understand overall network characteristics including power infrastructure, geography, accessibility infrastructure, environment, logistics and operational parameters, and later, validated through several iterations.

Geocell has a network of total 877 base station sites and transmission sites across the country. Out of the total network, 763 sites are connected to commercial power and the remaining 114 sites are off-grid running on Diesel generators as primary power source.

The grid power supply scenario for the grid connected sites is reliable with power outages being very rare. Out of the 877 grid connected sites, only 292 sites have diesel generator (DG) backup and rely on DG power source for an average of 2.3 hours per day. Rest of the sites rely completely on commercial grid power supply. Geocell has implemented battery hybrid control for majority of the sites in their network.

The 114 off-grid sites in the network rely on diesel generator as primary power source and are implemented with DG-battery hybrid control mechanism. The average daily run of diesel generator is 12 hours taking into account batteries running 3 cycles per day on an average with planned battery autonomy of 4 hours.

After thorough analysis of the network data, GPM has concluded that the on-grid sites may not be considered for Green Power design and feasibility analysis as grid power supply is quite reliable. Therefore, only the 114 off-grid sites are considered for Green Power feasibility analysis. Generic recommendations have been proposed for the on-grid sites to completely remove the dependence on diesel generators.

*Network Analysis: Off-Grid Sites*

All the off-grid sites are indoor sites and green field sites. More than 60% of the sites have difficult accessibility due to mountainous terrain and extreme weather conditions during winter period. One in every three sites is more than 2kms away from the nearby grid location and another quarter of the sites do not have a nearby grid location. Revenue loss from site downtime is negligible as the average site availability is 99.86%.

The overall daily power requirement for a network of 114 off-grid sites is 5,550 kWh of which each site requires 34 kWh daily to power the telecom equipment while another 15 kWh are required daily for running the air-conditioner or heater (considering average run of 10 hours daily) to maintain the indoor room environment. The average site load is 2.89 kW of which telecom equipment load is 1.41 kW on an average.

The daily diesel OPEX incurred to run the network of 114 off-grid sites is 4,900 US$ with approx. 2,900 litres of diesel required daily (at an average daily DG run of 12 hours). This amounts to an environmental impact of 8 tons of CO2 emission on a daily basis. The average battery backup planned for a site is around 4 hours which requires 3 battery run cycles per day.

**Table 1: Network Analysis: Off-Grid Sites**

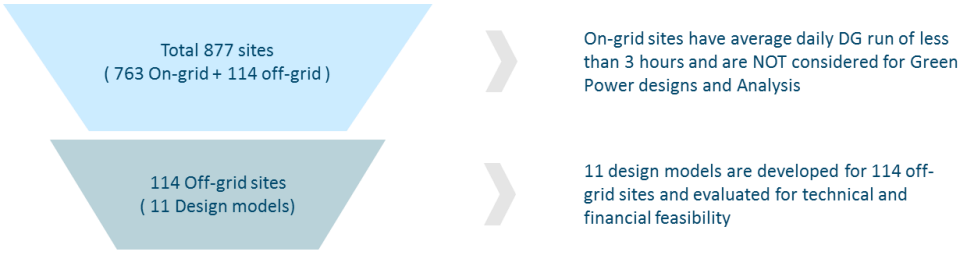
| | Network | Load | Power Source |
|---|---|---|---|
| Characteristics | ▪ All sites are indoor sites<br>▪ 41 are Hub sites, remaining 73 are terminal sites<br>▪ 17 are 3G sites (8 Hub and 9 Terminal)<br>▪ All sites are Green Field sites | ▪ Overall average site load of 2.89 kW<br>  ◦ Average telecoms load of 1.41 kW<br>▪ Overall Daily power requirement of 5,550 kWh | ▪ Daily DG run : 12.1 hours (avg. per site)<br>▪ Battery backup planned: 3.9 hours (avg. per site)<br>  ◦ Approx. 3 cycles per day |

| | | | |
|---|---|---|---|
| Observation | Accessibility<br>➢ More than 60% of the sites have difficult accessibility<br>Grid Extension<br>➢ ⅓ of the sites are more than 2 km from Grid<br>➢ Approx. ¼ of the sites have no Grid near by<br>Revenue and Site Availability<br>➢ Site availability ~ 99.86% (avg.)<br>➢ Revenue loss due to site downtime is negligible<br>➢ 114 off-grid sites contribute approx. 9% of total revenue for GEOCELL | ➢ Telecom equipment load requirement of 34 kWh per day<br>➢ Air-conditioner/heater load requirement of 15 kWh per day considering an avg. daily run of 10 hours<br>➢ ~30% of power requirement is for Air-conditioner/heater to maintain indoor room temperature | ➢ Daily diesel OPEX of ~ US$ 4,900<br>✓ Approx. 2,930 L of diesel consumed daily<br>✓ Daily DG run of 1,379 hours (Overall network)<br>➢ Daily CO2 emission of 8 Tons<br>➢ At 3 cycles per day, the battery life would be ~ 2 years. [ @ 2200 cycles at 60% DoD ] |

### Model Design & Solutions

Based on the overall network data analysis, GPM has considered the 114 off-grid sites for renewable power solution design and feasibility analysis. The overall approach to design modelling is highlighted below.

**Figure 1: Design Approach**




APPROACH

Site grouping
1. 114 sites are divided into 4 renewable energy groups based on renewable energy potential at each site
   - ❑ Each group has similar renewable energy resource for potential design
2. The sites in each renewable energy group are re-grouped based on load characteristics

Design models
- ❑ 11 design models are developed based on the site grouping
- ❑ Each model represents similar renewable resource and load characteristics across modelled group of sites
- ❑ Business cases are developed for each model to analyse financial feasibility and returns

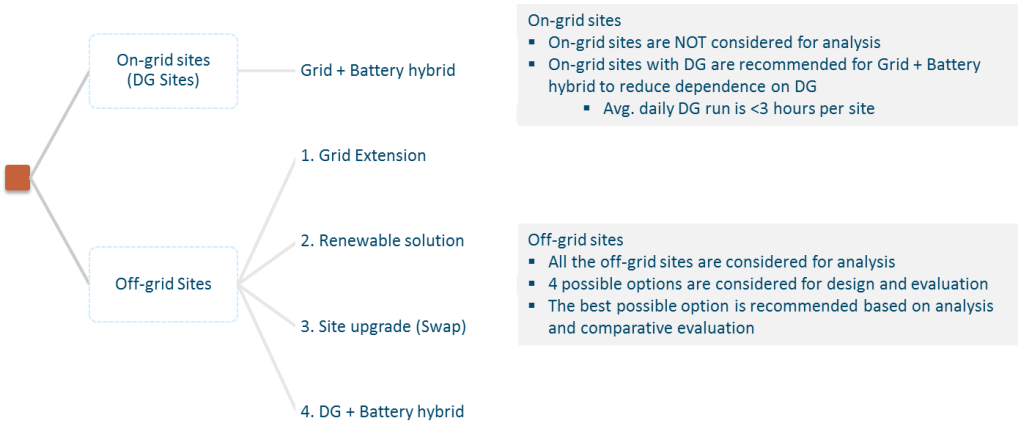
Overall the 114 off-grid sites are first grouped based on similar renewable resource potential and later regrouped based on site load characteristics for solution design and dimensioning. Thus, 11 design models are developed based on the site grouping. Each design model represents similar characteristics (renewable resource and load) across modelled group of sites.

## Solution Analysis and Evaluation

Every green power design thus developed is considered for comparison and evaluation against other possible alternate options. Four possible solution options are evaluated against each other for all the off-grid sites considered for green power solution design.

For each design model representing a group of modelled sites, site-by-site evaluation of solution options is performed and the best feasible solution option is chosen for a particular site in the design group. The evaluation approach and the solution options considered are highlighted below.

**Figure 2: Options Evaluation Approach**

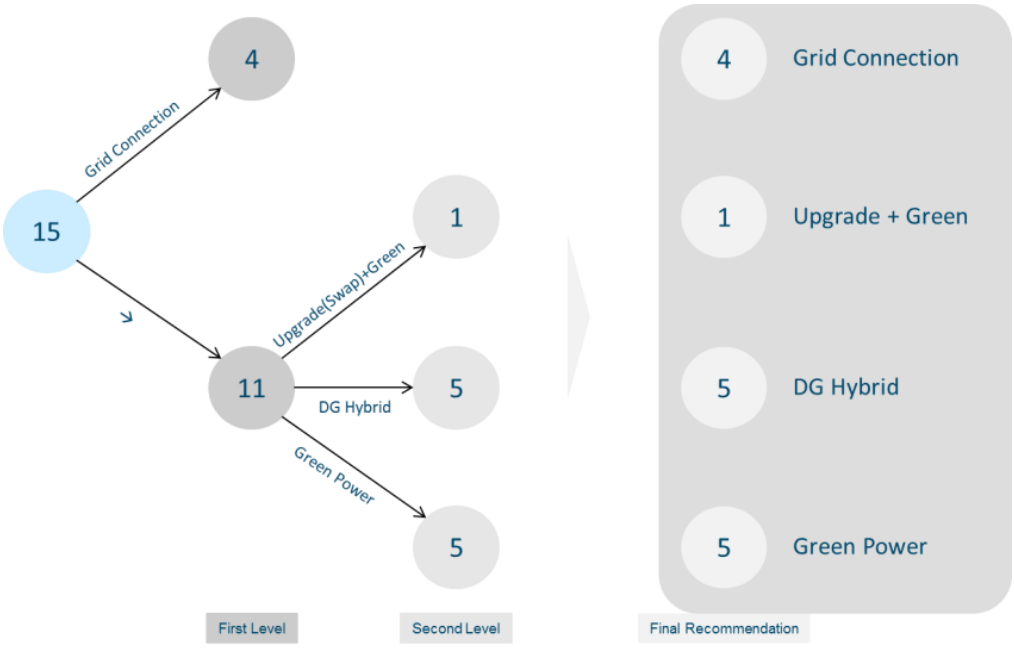


## Business Cases and Financial Evaluation

Business cases are developed for each design model over a 10 year business plan and compared against other solution options. 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.

The evaluation approach and a sample evaluation are presented below.

**Figure 3: Options Analysis Sample**




- At 1st level, every site in the design model is evaluated for grid extension based on grid connection parity distance. All the sites falling within the grid connection parity distance are recommended for Grid Extension
- At 2nd level, the green power designs for the remaining sites are evaluated against upgrade scenario and existing DG + Battery hybrid case. The option with better feasibility indicators is selected respective sites.

Based on design analysis and comparative evaluation of different solution options, each site is recommended with the best feasible solution.

**Prioritization & Investment Plan**

After careful analysis, solution design and evaluation of options, the sites are grouped into implementation priorities for phased deployment. Two levels of implementation prioritization are considered.

One, based on site characteristics including BH Traffic, Site Traffic, Site importance and Geographic Accessibility. Sites with higher traffic, high importance (3G and Hub sites) and difficult accessibility are ordered higher in priority for implementation.

Second, prioritization based on financial feasibility, OPEX reduction and Environmental Impact. Sites with better financial indicators such as smaller payback period and higher OPEX reduction are given higher priority. Also, green sites are given higher rank in prioritization as compared to DG + battery hybrid sites.

Based on the prioritization criteria, 4 implementation priorities are proposed. Every priority is supported with investment plan and financial analysis.

## Results & 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 site engineering and operations team.

### Energy Solution Recommendations

After thorough design, analysis and evaluation of possible solution options, GPM has come up with the following solution recommendations for 114 off-grid sites in Geocell's network. The table below shows the number of sites proposed in each category of solution option.

| Final Recommended Sites | | | | |
|---|---|---|---|---|
| **Design Model** | **Grid Extension** | **Green Power** | **DG + Battery hybrid** | **Upgrade+Green** |
| 1a | 5 | 8 | 0 | 0 |
| 1b | 1 | 6 | 0 | 0 |
| 1cd | 4 | 12 | 0 | 0 |
| 2a | 4 | 5 | 5 | 1 |
| 2b | 8 | 0 | 3 | 0 |
| 2cd | 6 | 6 | 2 | 3 |
| 3ab | 10 | 0 | 4 | 0 |
| 3cd | 3 | 0 | 3 | 0 |
| 4ab | 5 | 0 | 0 | 0 |
| 4cd | 4 | 0 | 2 | 0 |
| 5abc | 3 | 0 | 1 | 0 |
| **Total** | **53** ① | **37** ② | **20** ③ | **4** ④ |

A total of 41 sites have been proposed for Green Power solution and include 37 existing sites with green power solution and 4 upgraded sites with green power solution. 53 sites have been recommended for connecting to the commercial grid as the most feasible option. The remaining 20 sites will be deployed DG + battery hybrid power solution since they are feasible for green power or grid extension.

### Solution dimensions

The solution dimensions for all the 11 design models developed are presented below for both existing and site upgrade scenario. Each design proposes optimum solution dimension and equipment sizes to minimize the cost of energy produced and maximum utilization of the energy generated.

Table 2: Solution and Equipment dimensions: Existing Scenario and Upgraded Scenario

| Design Model | | | Existing Load ( Model load + Aircon/heater Load) | | | | | | Upgraded Scenario (Model load only) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of Sites | Model | Model Load (kW) | PV (kW) | Wind (kW) | Battery (Ah) | DG (KVA) | Controller | Converter | PV (kW) | Wind (kW) | Battery (Ah) | DG (KVA) | Controller | Converter |
| 13 | 1a | 0.8 | 8.64 | - | 2 x 800 | 15 | 180 A | 8 kW | 5.76 | - | 1 x 600 | 15 | 120 A | 6 kW |
| 7 | 1b | 0.8 | 5.76 | 3 | 2 x 600 | 15 | 120 A | 8 kW | 2.88 | 3 | 1 x 600 | 15 | 60 A | 6 kW |
| 16 | 1cd | 0.8 | 5.04 | 3 | 2 x 600 | 15 | 125 A | 8 kW | 2.16 | 3 | 1 x 600 | 15 | 50 A | 4 kW |
| 15 | 2a | 1.3 | 9.36 | - | 2 x 800 | 15 | 200 A | 12 kW | 7.2 | - | 2 x 800 | 15 | 150 A | 10 kW |
| 11 | 2b | 1.3 | 9.36 | 3 | 2 x 800 | 15 | 200 A | 10 kW | 5.04 | 3 | 1 x 800 | 15 | 100 A | 8 kW |
| 17 | 2cd | 1.3 | 5.04 | 6 | 2 x 600 | 15 | 125 A | 8 kW | 4.32 | 3 | 2 x 600 | 15 | 100 A | 8 kW |
| 14 | 3ab | 1.9 | 9.36 | 6 | 2 x 800 | 15 | 200 A | 10 kW | 7.92 | 3 | 2 x 800 | 15 | 160 A | 12 kW |
| 6 | 3cd | 1.9 | 6.48 | 6 | 2 x 800 | 15 | 150 A | 12 kW | 4.32 | 6 | 2 x 800 | 15 | 100 A | 10 kW |
| 5 | 4ab | 2.4 | 9.36 | 6 | 2 x 800 | 15 | 200 A | 12 kW | 9.36 | 3 | 2 x 800 | 15 | 200 A | 12 kW |
| 6 | 4cd | 2.4 | 7.92 | 6 | 2 x 800 | 15 | 150 A | 12 kW | 4.32 | 6 | 2 x 800 | 15 | 100 A | 14 kW |
| 4 | 5abc | 3.3 | 0 | 0 | (Existing) | 15 | - | 0 kW | 0 | 0 | (Existing) | 15 | - | 0 kW |

### Implementation Priorities

Based on the final recommendations, the sites have been grouped into implementation priorities to assist in investment planning and phased deployment of the recommended solutions. The prioritization is performed based on the prioritization criteria explained in earlier sections. A total of 4 priorities are derived covering 53 sites proposed for grid connection and 41 sites proposed for green power. The remaining 20 sites recommended for DG-battery hybrid are given no priority or last priority in the order of implementation.

The below table summarizes the priority-wise performance indicators for 41 sites proposed with green power solutions.

Table 3: Priority Summary: Green Sites

| Priority | Number of Sites | Energy contribution (Avg) | | | Battery Autonomy (Avg. Hrs) | DG run ( Avg. Hrs/yr per site) | Diesel Savings (L/yr) | Green Power Generation (kWh/yr) | CO2 Emission Reduction (tonnes/yr) | Payback Period (yr) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Solar | Wind | DG | | | | | | |
| 1 | 6 | 59% | 24% | 18% | 28.3 | 312 | 51,202 | 73,845 | 133 | 3.00 |
| 2 | 16 | 54% | 29% | 17% | 28.3 | 295 | 128,663 | 197,356 | 356 | 3.12 |
| 3 | 4 | 51% | 35% | 14% | 28.3 | 244 | 31,993 | 52,123 | 88 | 3.13 |
| 4 | 15 | 41% | 38% | 21% | 23.7 | 394 | 141,612 | 258,555 | 377 | 3.49 |
| **Total** | **41** | | | | | | **353,470** | **581,879** | **954** | |

### Investment plan

The 41 sites proposed with green power solution are presented with priority-wise detailed analysis 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 priority-wise investments, performance indicators and financial returns are given below for the 41 green sites.

Table 4: Priority wise Investment summary

**Priority Financial Summary**

| Priority | No. of sites | CAPEX ($) | OPEX ($/yr) | OPEX Saving ($/yr) | Payback period (Yrs) | ROI (%) | IRR (%) | NPV ($) |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 67,785 | 1,731 | 22,587 | 3.00 | 34% | 30% | 36,859 |
| 2 | 16 | 71,156 | 1,668 | 22,837 | 3.12 | 32% | 29% | 34,873 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | 4 | 70,327 | 1,433 | 22,513 | 3.13 | 32% | 29% | 34,763 | |
| 4 | 15 | 79,625 | 2,291 | 22,772 | 3.49 | 29% | 26% | 26,918 | |
| Overall | 41 | 73,680 | 1,882 | 22,745 | 3.24 | 31% | 28% | 32,243 | Per Site |
| | | 3,020,886 | 77,159 | 932,552 | | | | | Total |

**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 Geocell to reduce their energy requirement at every site.

Below are some of the generic recommendations to optimize and reduce energy requirement and improve equipment performance.

- Upgrade or swap indoor equipment to outdoor equipment for Off-grid sites
    - Reduce overall site load and optimize energy requirements
    - Improve equipment performance for extreme weather conditions
- Replace old diesel generators for improved performance and reduced O&M costs
    - Reduce fuel consumption
    - Reduce number of site visits and reduce operational expenses
    - Improve performance during extreme weather conditions especially during winter
- Implement smart energy monitoring and site equipment control mechanism to control site operations
- Implement smart power source control mechanism to intelligently select between various power sources including Renewables, Grid power, Batteries and DG

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

**Summary**

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

| | |
|---|---|
| Green Power Solution Recommended for | 41 Off-grid Sites |
| Grid extension recommended for | 53 Off-grid Sites |
| Recommend DG + Battery hybrid for | 20 Off-grid sites |
| No Green Power Recommendation for | On-grid Sites |
| A list of generic recommendations those can save up to 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$ 3.02 million |
| Current Energy OPEX for all sites | US$ 1.01 million/yr |
| Energy OPEX post Green Power deployment | US$ 0.08 million/yr |
| OPEX Savings by implementing Green Power Solutions | US$ 0.93 million/yr |
| Average Pay back period | 3.24 years |
| Average NPV | US$ 32,243 |
| Average ROI | 31.0% |
| **Reduction in CO2 emissions** | **954 Tons/yr** |

## GSMA Green Power for Mobile Programme

*Promoting Green Power to Extend Mobile beyond the Grid*

Green Power for Mobile is a joint IFC and GSMA Development Fund programme which, in partnership with the Ministry of Foreign Affairs of the Netherlands, promotes the use of green power, such as solar and wind, at mobile network tower sites in remote rural areas around the world, where there is limited or no grid power.

There are about 640,000 off-grid sites globally, primarily powered by diesel generators, out of which 120,000 could be eligible for green power solutions. IFC, a member of the World Bank Group, is the largest global development institution focused exclusively on the private sector.

GSMA is the industry association which represents the interests of nearly 800 mobile operators worldwide, serving more than 6 billion connections and 4 billion individual subscribers.

**Figure 4 – 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/developmentfund/programmes/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



Development Fund