

Green Power Feasibility Study: XXXX

Technical and Financial Analysis

May-2012

By xxxxxx xxxxxx

Title

IFC

Supported by the Netherlands

Green Power for Mobile

Restricted - Confidential Information

© GSMA 2012

All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

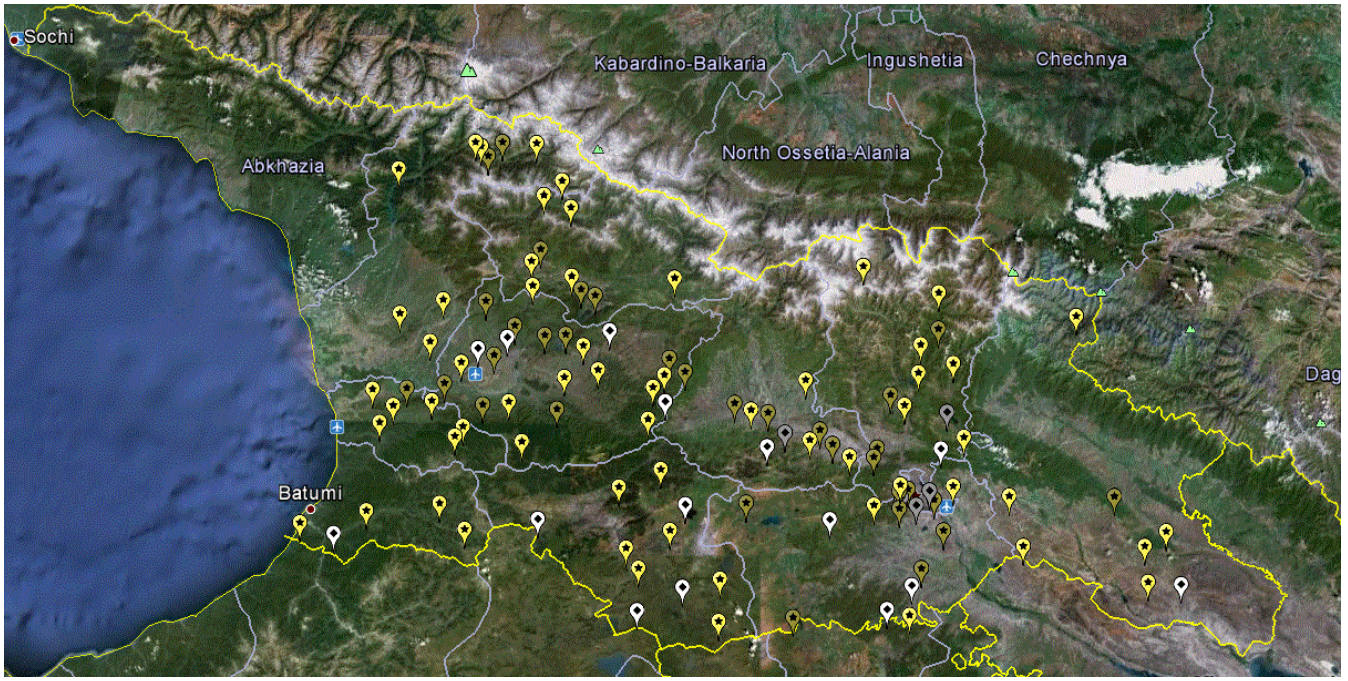
Agenda

- **Overall Network Data Analysis**
- Overall Context Analysis
- Renewable Resource Analysis
- Design Modeling and Business Cases
- Analysis and Recommendations
- Prioritization and Financials
- Overall Summary

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Overall Network Data Analysis

- The complete network of existing sites is considered for the analysis
- Relevant data for complete network is collected and validated for the analysis
- Site survey is carried out for selected sample of sites to get field level understanding of the network
- Overall characteristics of the network including power infrastructure, geography, accessibility infrastructure, environment, logistics and operational parameters have been taken into consideration for the analysis



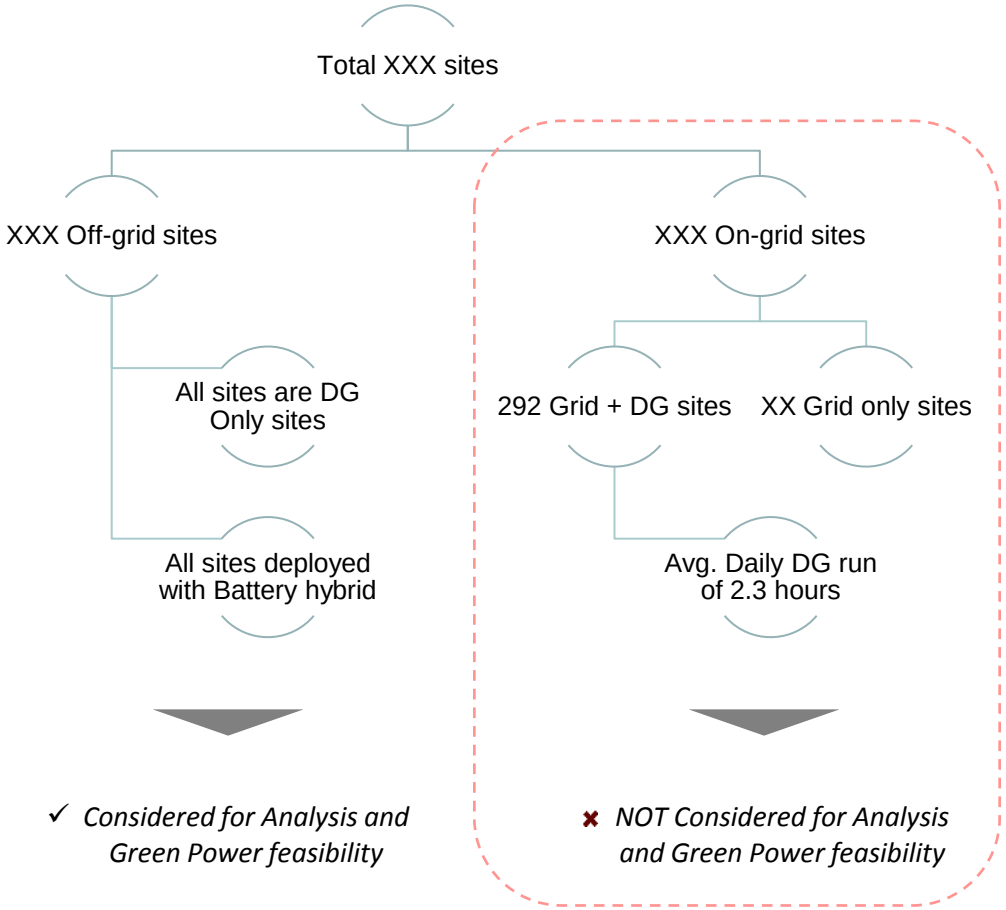
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Overall Network Data Analysis

Network Analysis

- All sites are indoor sites
- XX are Hub sites, remaining XX are terminal sites
- XX are 3G sites (8 Hub and 9 Terminal)
- All sites are Green Field sites

- *Accessibility*
  - ✓ *More than 60% of the sites have difficult accessibility*
- *Grid Extension*
  - ✓ *⅓ of the sites are more than 2 km from Grid*
  - ✓ *Approx. ¼ of the sites have no Grid near by*
- *Revenue and Site Availability*
  - ✓ *Site availability ~ 99.86% (avg.)*
  - ✓ *Avg. daily revenue per site: ~378 $ for Hub sites and ~279 $ for terminal sites*
  - ✓ *Revenue loss due to site downtime is negligible*



© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Overall Network Data Analysis

Load Analysis

- ❑ Overall average site load of 2.89 kW
  - ✓ Average telecoms load of 1.41 kW
- ❑ Overall Daily power requirement of 5,550 kWh
  - ✓ ~30% of power requirement is for Aircon

Power Source Analysis

- ➢ **Daily diesel OPEX of ~ US$ 4,900**
- ➢ **Daily CO2 emission of 70 Tons**

- ➢ Approx. 2,930 L of diesel consumed daily
- ➢ Daily DG run of 1,379 hours (Overall network)
- ➢ At 3 cycles per day, the battery life would be ~ 2 years. [@ 2200 cycles at 60% DoD]

- ❑ Daily DG run : 12.1 hours (avg. per site)
- ❑ Battery backup planned: 3.9 hours (avg. per site)
  - ✓ Approx. 3 cycles per day

Load Analysis			
Per site	**Load (avg. kW)**	**Daily kWh**	**%**
Telecoms equipment	1.41	34	
Air conditioner	1.48	15 **	**30%**
Overall	**2.89**	**49**	
**@ avg. 10 hours/day run			

Diesel Generator Usage		
	per site	Overall
Daily DG run (hrs)	12.1	1,379
Daily diesel (L)	26	2,930
Daily diesel OPEX ($)	43	4,900
Yearly Diesel OPEX ($)	**15,687**	**1,788,363**

CO2 Emission	7.9	Ton per day
	2,867	Ton per year

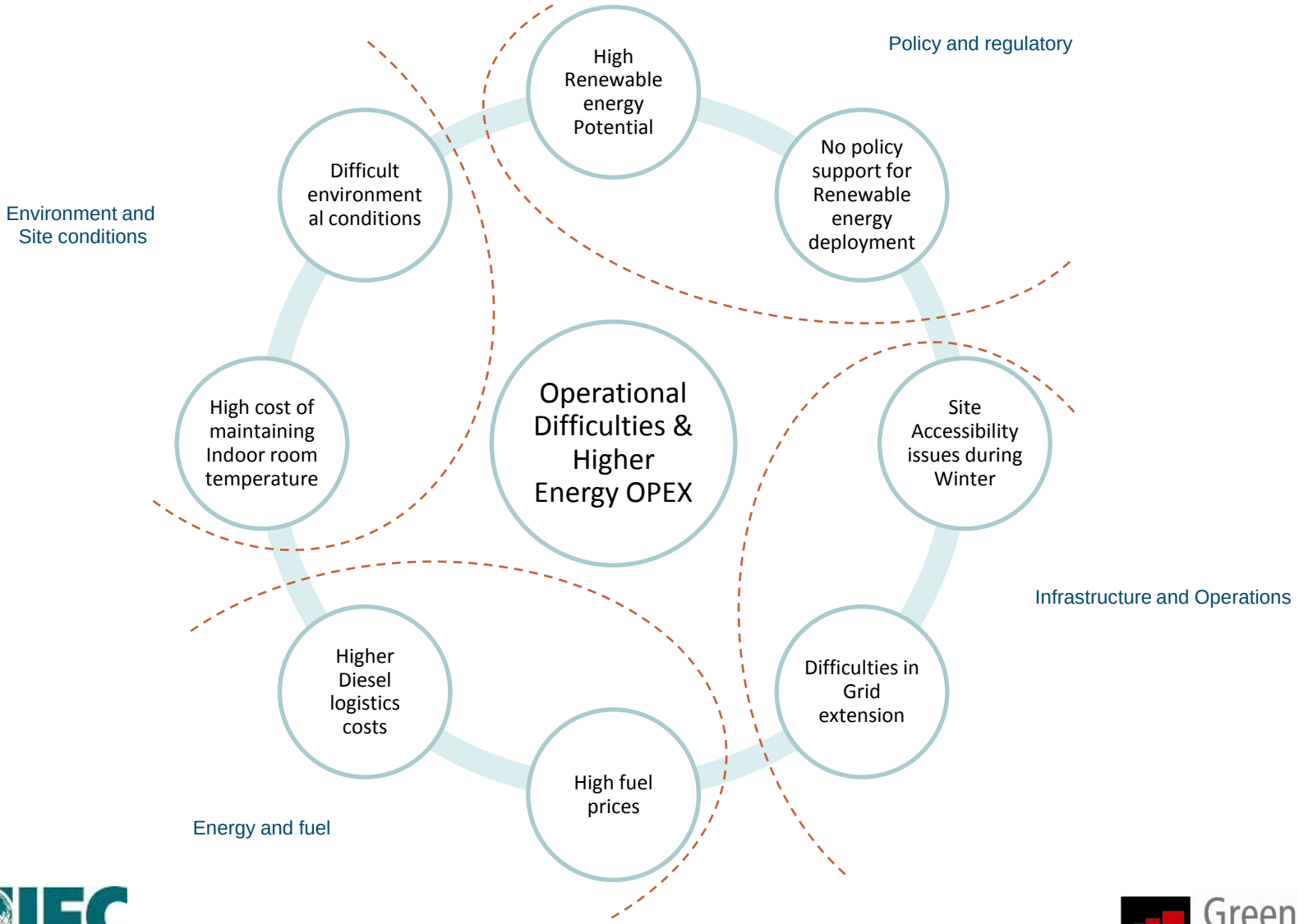
Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Agenda

- Overall Network Data Analysis
- **Overall Context Analysis**
- Renewable Resource Analysis
- Design Modeling and Business Cases
- Analysis and Recommendations
- Prioritization and Financials
- Overall Summary

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Overall Context Analysis



© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Overall Context Analysis

Network	XXX of XXX sites are in off-grid locations	
	All off-grid sites are indoor sites with high power requirements	
	Higher energy OPEX contributed by equipment to maintain working temperature conditions	Ambient temperature ranges from approx. -13 ^{o}C to +40 ^{o}C Equipment working temperature ranges from +5 ^{o}C to +45 ^{o}C
Operations	More than 60% of off-grid sites are with difficult accessibility	
	Higher operational costs during winter due difficulties in site accessibility	
	Diesel generators require regular site visits for preventive and corrective maintenance	
Country & Regulatory	More than 95% of energy production is from renewable sources majorly from hydro power plants	
	No policy framework and support for renewable energy resources like wind despite good potential	
	Higher electricity costs of grid electricity	

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

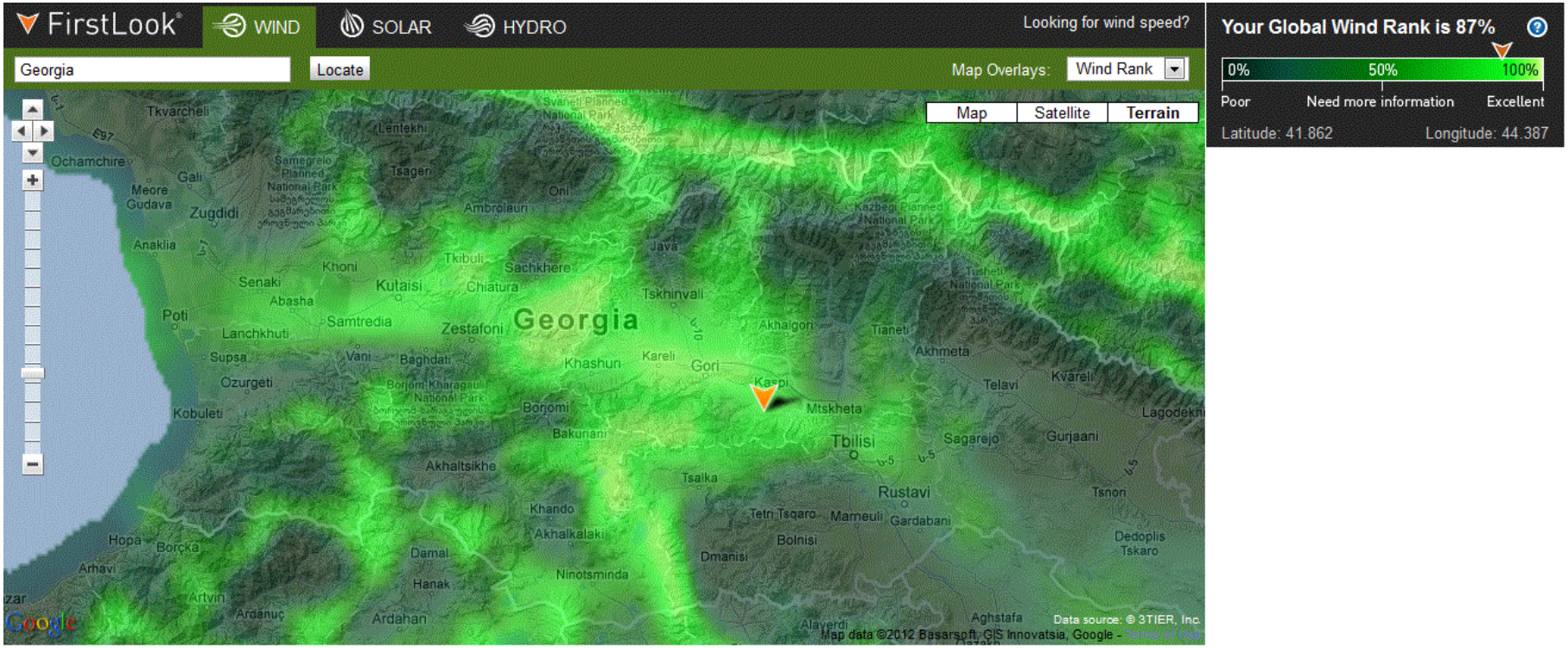
Agenda

- Overall Network Data Analysis
- Overall Context Analysis
- **Renewable Resource Analysis**
- Design Modeling and Business Cases
- Analysis and Recommendations
- Prioritization and Financials
- Overall Summary

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Renewable Resource Analysis

Wind Speed: Country Name

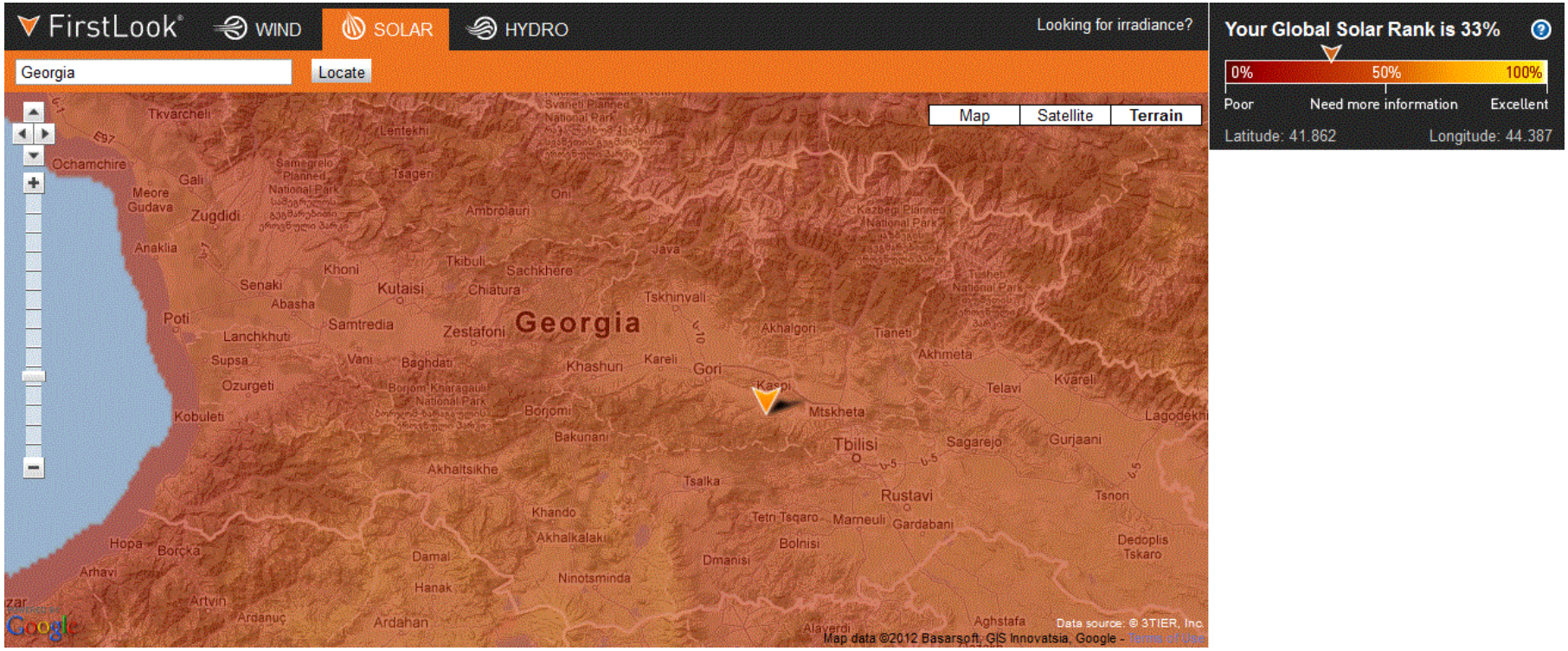


Source: 3 Tier, Wind Source

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Renewable Resource Analysis

Solar Irradiance: Country Name



Source: 3 tier, Solar Radiation

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Renewable Resource Analysis

S.No.	Name	Latitude - N	Longitude - E	Monthly Avg. Wind Speed (m/s) at @50m													Monthly Avg. Solar Radiation (kWh/sq.m/day)													Group
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
1				5.8	5.8	5.2	5.1	4.9	4.7	5.3	5.4	5.2	5.1	5.5	5.8	5.3	1.7	2.5	3.5	4.3	5.3	5.6	5.7	5.1	4.2	3.0	2.0	1.4	3.7	b
2				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
3				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
4				6.8	7.1	6.6	6.3	6.0	6.0	6.6	6.8	6.4	6.4	6.8	7.1	6.6	1.8	2.7	3.7	4.5	5.4	5.8	5.6	4.9	4.1	3.1	2.1	1.6	3.8	c
5				5.0	4.8	4.2	4.2	4.0	3.6	4.0	4.1	4.1	4.2	4.5	4.8	4.3	1.8		3.7	4.5	5.3	5.6	5.7	5.1	4.2	3.1	2.0	1.5	3.8	a
6				6.2	6.6	6.1	5.9	5.6	5.7	6.5	6.6	6.0	6.0	6.3	6.5	6.2	2.0	2.8	3.7	4.4	5.2	5.8	5.7	5.1	4.2	3.1	2.1	1.6	3.8	c
7				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
8				5.4	5.5	4.9	4.8	4.6	4.6	5.3	5.3	5.0	4.8	5.2	5.4	5.1	1.8	2.7	3.5	4.3	5.3	6.1	6.1	5.5	4.6	3.3	2.1	1.5	3.9	b
9				6.8	7.1	6.6	6.3	6.0	6.0	6.6	6.8	6.4	6.4	6.8	7.1	6.6	1.8	2.7	3.7	4.5	5.4	5.8	5.6	4.9	4.1	3.1	2.1	1.6	3.8	c
10				6.9	7.5	7.1	6.8	6.3	6.6	7.4	7.5	6.9	6.8	7.2	7.4	7.0	2.1	2.9	3.8	4.7	5.6	6.3	6.0	5.2	4.2	3.1	2.2	1.7	4.0	d
11				6.8	7.1	6.6	6.3	6.0	6.0	6.6	6.8	6.4	6.4	6.8	7.1	6.6	1.8	2.7	3.7	4.5	5.4	5.8	5.6	4.9	4.1	3.1	2.1	1.6	3.8	c
12				6.2	6.6	6.1	5.9	5.6	5.7	6.5	6.6	6.0	6.0	6.3	6.5	6.2	2.0	2.8	3.7	4.4	5.2	5.8	5.7	5.1	4.2	3.1	2.1	1.6	3.8	c
13				5.8	5.8	5.2	5.1	4.9	4.7	5.3	5.4	5.2	5.1	5.5	5.8	5.3	1.7	2.5	3.5	4.3	5.3	5.6	5.7	5.1	4.2	3.0	2.0	1.4	3.7	b
14				5.4	5.5	4.9	4.8	4.6	4.6	5.3	5.3	5.0	4.8	5.2	5.4	5.1	1.8	2.7	3.5	4.3	5.3	6.1	6.1	5.5	4.6	3.3	2.1	1.5	3.9	b
15				5.8	5.8	5.2	5.1	4.9	4.7	5.3	5.4	5.2	5.1	5.5	5.8	5.3	1.7	2.5	3.5	4.3	5.3	5.6	5.7	5.1	4.2	3.0	2.0	1.4	3.7	b
16				6.8	7.1	6.6	6.3	6.0	6.0	6.6	6.8	6.4	6.4	6.8	7.1	6.6	1.8	2.7	3.7	4.5	5.4	5.8	5.6	4.9	4.1	3.1	2.1	1.6	3.8	c
17				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
18				5.8	5.8	5.2	5.1	4.9	4.7	5.3	5.4	5.2	5.1	5.5	5.8	5.3	1.7	2.5	3.5	4.3	5.3	5.6	5.7	5.1	4.2	3.0	2.0	1.4	3.7	b
19				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
20				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
21				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
22				6.8	7.1	6.6	6.3	6.0	6.0	6.6	6.8	6.4	6.4	6.8	7.1	6.6	1.8	2.7	3.7	4.5	5.4	5.8	5.6	4.9	4.1	3.1	2.1	1.6	3.8	c
23				6.2	6.6	6.1	5.9	5.6	5.7	6.5	6.6	6.0	6.0	6.3	6.5	6.2	2.0	2.8	3.7	4.4	5.2	5.8	5.7	5.1	4.2	3.1	2.1	1.6	3.8	c
24				5.4	5.5	4.9	4.8	4.6	4.6	5.3	5.3	5.0	4.8	5.2	5.4	5.1	1.8	2.7	3.5	4.3	5.3	6.1	6.1	5.5	4.6	3.3	2.1	1.5	3.9	b
25				5.0	4.8	4.2	4.2	4.0	3.6	4.0	4.1	4.1	4.2	4.5	4.8	4.3	1.8		3.7	4.5	5.3	5.6	5.7	5.1	4.2	3.1	2.0	1.5	3.8	a
26				7.4	8.1	7.7	7.4	6.9	7.2	8.1	8.2	7.4	7.4	7.8	8.0	7.6	2.1		3.9	5.0	6.0	6.7	6.3	5.5	4.5	3.2	2.2	1.8	4.2	d
27				6.9	7.5	7.1	6.8	6.3	6.6	7.4	7.5	6.9	6.8	7.2	7.4	7.0	2.1	2.9	3.8	4.7	5.6	6.3	6.0	5.2	4.2	3.1	2.2	1.7	4.0	d
28				5.4	5.1	4.3	4.3	4.1	4.0	4.7	4.7	4.4	4.2	4.8	5.1	4.6	1.6		3.2	4.2	5.3	5.9	5.5	4.8	4.1	2.9	1.9	1.4	3.6	b
29				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7		3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
30				6.8	7.1	6.6	6.3	6.0	6.0	6.6	6.8	6.4	6.4	6.8	7.1	6.6	1.8	2.7	3.7	4.5	5.4	5.8	5.6	4.9	4.1	3.1	2.1	1.6	3.8	c

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Renewable Resource Analysis

S.No.	Name	Latitude - N	Longitude - E	Monthly Avg. Wind Speed (m/s) at @50m													Monthly Avg. Solar Radiation (kWh/sq.m/day)													Group
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
91				6.9	7.5	7.1	6.8	6.3	6.6	7.4	7.5	6.9	6.8	7.2	7.4	7.0	2.1	2.9	3.8	4.7	5.6	6.3	6.0	5.2	4.2	3.1	2.2	1.7	4.0	d
92				6.8	7.1	6.6	6.3	6.0	6.0	6.6	6.8	6.4	6.4	6.8	7.1	6.6	1.8	2.7	3.7	4.5	5.4	5.8	5.6	4.9	4.1	3.1	2.1	1.6	3.8	c
93				5.8	5.8	5.2	5.1	4.9	4.7	5.3	5.4	5.2	5.1	5.5	5.8	5.3	1.7	2.5	3.5	4.3	5.3	5.6	5.7	5.1	4.2	3.0	2.0	1.4	3.7	b
94				5.4	5.5	4.9	4.8	4.6	4.6	5.3	5.3	5.0	4.8	5.2	5.4	5.1	1.8	2.7	3.5	4.3	5.3	6.1	6.1	5.5	4.6	3.3	2.1	1.5	3.9	b
95				4.6	4.3	3.7	3.7	3.7	3.4	4.0	4.0	3.9	3.7	4.1	4.3	4.0	1.7	2.4	3.4	4.3	5.3	5.9	5.7	5.2	4.4	3.1	2.0	1.4	3.7	a
96				6.2	6.6	6.1	5.9	5.6	5.7	6.5	6.6	6.0	6.0	6.3	6.5	6.2	2.0	2.8	3.7	4.4	5.2	5.8	5.7	5.1	4.2	3.1	2.1	1.6	3.8	c
97				5.4	5.5	4.9	4.8	4.6	4.6	5.3	5.3	5.0	4.8	5.2	5.4	5.1	1.8	2.7	3.5	4.3	5.3	6.1	6.1	5.5	4.6	3.3	2.1	1.5	3.9	b
98				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
99				6.2	6.6	6.1	5.9	5.6	5.7	6.5	6.6	6.0	6.0	6.3	6.5	6.2	2.0	2.8	3.7	4.4	5.2	5.8	5.7	5.1	4.2	3.1	2.1	1.6	3.8	c
100				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
101				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
102				5.4	5.5	4.9	4.8	4.6	4.6	5.3	5.3	5.0	4.8	5.2	5.4	5.1	1.8	2.7	3.5	4.3	5.3	6.1	6.1	5.5	4.6	3.3	2.1	1.5	3.9	b
103				5.0	4.8	4.2	4.2	4.0	3.6	4.0	4.1	4.1	4.2	4.5	4.8	4.3	1.8		3.7	4.5	5.3	5.6	5.7	5.1	4.2	3.1	2.0	1.5	3.8	a
104				6.2	6.6	6.1	5.9	5.6	5.7	6.5	6.6	6.0	6.0	6.3	6.5	6.2	2.0	2.8	3.7	4.4	5.2	5.8	5.7	5.1	4.2	3.1	2.1	1.6	3.8	c
105				6.2	6.6	6.1	5.9	5.6	5.7	6.5	6.6	6.0	6.0	6.3	6.5	6.2	2.0	2.8	3.7	4.4	5.2	5.8	5.7	5.1	4.2	3.1	2.1	1.6	3.8	c
106				6.9	7.5	7.1	6.8	6.3	6.6	7.4	7.5	6.9	6.8	7.2	7.4	7.0	2.1	2.9	3.8	4.7	5.6	6.3	6.0	5.2	4.2	3.1	2.2	1.7	4.0	d
107				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
108				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
109				5.4	5.5	4.9	4.8	4.6	4.6	5.3	5.3	5.0	4.8	5.2	5.4	5.1	1.8	2.7	3.5	4.3	5.3	6.1	6.1	5.5	4.6	3.3	2.1	1.5	3.9	b
110				6.2	6.6	6.1	5.9	5.6	5.7	6.5	6.6	6.0	6.0	6.3	6.5	6.2	2.0	2.8	3.7	4.4	5.2	5.8	5.7	5.1	4.2	3.1	2.1	1.6	3.8	c
111				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
112				4.8	4.5	3.8	3.8	3.8	3.4	3.9	4.0	4.0	3.8	4.3	4.5	4.0	1.7	2.4	3.4	4.3	5.4	5.7	5.6	5.0	4.2	3.0	2.0	1.4	3.7	a
113				6.8	7.1	6.6	6.3	6.0	6.0	6.6	6.8	6.4	6.4	6.8	7.1	6.6	1.8	2.7	3.7	4.5	5.4	5.8	5.6	4.9	4.1	3.1	2.1	1.6	3.8	c
114	S			6.2	6.6	6.1	5.9	5.6	5.7	6.5	6.6	6.0	6.0	6.3	6.5	6.2	2.0	2.8	3.7	4.4	5.2	5.8	5.7	5.1	4.2	3.1	2.1	1.6	3.8	c

- ✓ Average Wind Speed is 5.3 m/s (ranges from 4 m/s to 7.6 m/s) at 50m anemometer height
- ✓ Average Solar radiation is 3.8 kWh/day/sq.m.

Solar and Wind Hybrid solutions can be considered for design and feasibility analysis

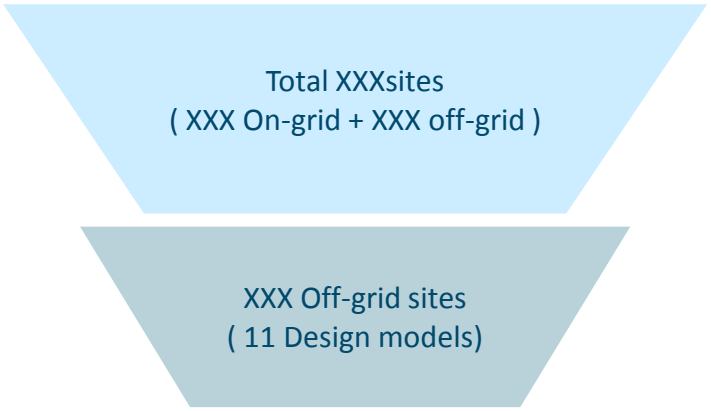
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Agenda

- Overall Network Data Analysis
- Overall Context Analysis
- Renewable Resource Analysis
- **Design Modeling and Business Cases**
- Analysis and Recommendations
- Prioritization and Financials
- Overall Summary

Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Design Modeling: *Overview*



On-grid sites have average daily DG run of less than 3 hours and are NOT considered for Green Power designs and Analysis

11 design models are developed for XXX off-grid sites and evaluated for technical and financial feasibility

APPROACH

Site grouping

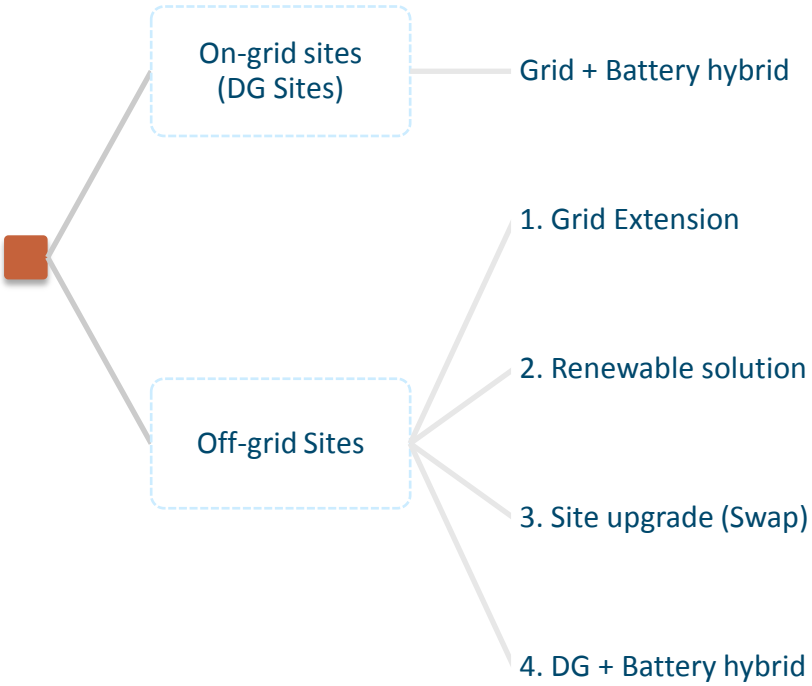
1. XXX sites are divided into 4 renewable energy groups based on renewable energy potential at each site
   - ❑ Each group has similar renewable energy resource for potential design
2. The sites in each renewable energy group are re-grouped based on load characteristics

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

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Design Modeling: *Overview*



On-grid sites

- On-grid sites are NOT considered for analysis
- On-grid sites with DG are recommended for Grid + Battery hybrid to reduce dependence on DG
  - Avg. daily DG run is <3 hours per site

Off-grid sites

- All the off-grid sites are considered for analysis
- 4 possible options are considered for design and evaluation
- The best possible option is recommended based on analysis and comparative evaluation

Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

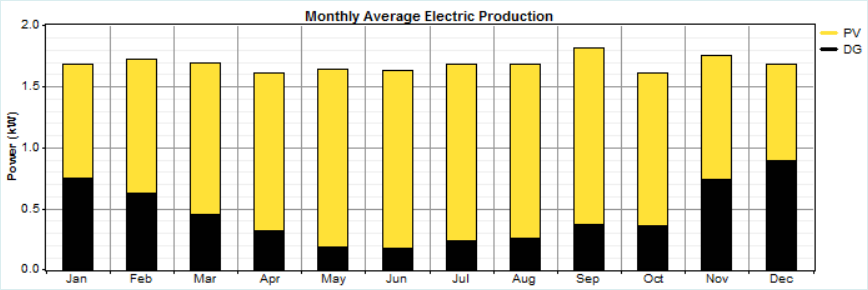
Design Models

Model: 1a

1a (13 Sites)		
	Design Model	**1a**
	Homer Model Load	0.8 kW
Sites Considered	**ID sites**	13
	OD sites	0
	3G sites	0
	Fixed DG sites	13
Exisitng Load Considered	**BTS Load**	440-880W
	TxRx Load	110/177/370W
	3G Load	-
Additional Load Considered	**Battery Cooler**	-
	Aircon/Heater (@10hrs/day)	1.5 kW
Power Scenario considered	**Generator**	15/20KVA
	Grid Status	Off-grid
	Avg. Daily DG Run	11.65 hrs
Site Availability & Revenue Loss	**Avg. site Availability**	99.90%
	Avg. Daily Voice Traffic Lost (Erl/Site)	0
	Avg. Daily Data Traffic Lost (MB/Site)	0
	Revenue Loss ($/Site/year)	0

DESIGN

Proposed System Architecture	
PV	8.64 kW (48 x 180W)
Wind	-
Generator	15 KVA (or Existing)
Controller	180 Amps
Battery @48V	2 x 600 Ah (OPzS or Equivalent)
Rectifier	8 kW
Inverter	8 kW



Renewable indicators	
Autonomy	28.30 hrs
Excess Electricity	4.45%
DG hours of Operation	446 hrs / yr
Renewable Generation	10,861 kWh / yr
Contribution to Energy	PV: 74%
	Wind: 0%
	DG: 26%

Environmental Indicators		
Diesel Solution CO2 Emission	25.30	Ton per site / yr
Renewable Solution CO2 Emission	2.76	Ton per site / yr
Reduce CO2 Emission of	22.54	Ton per site / yr

Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

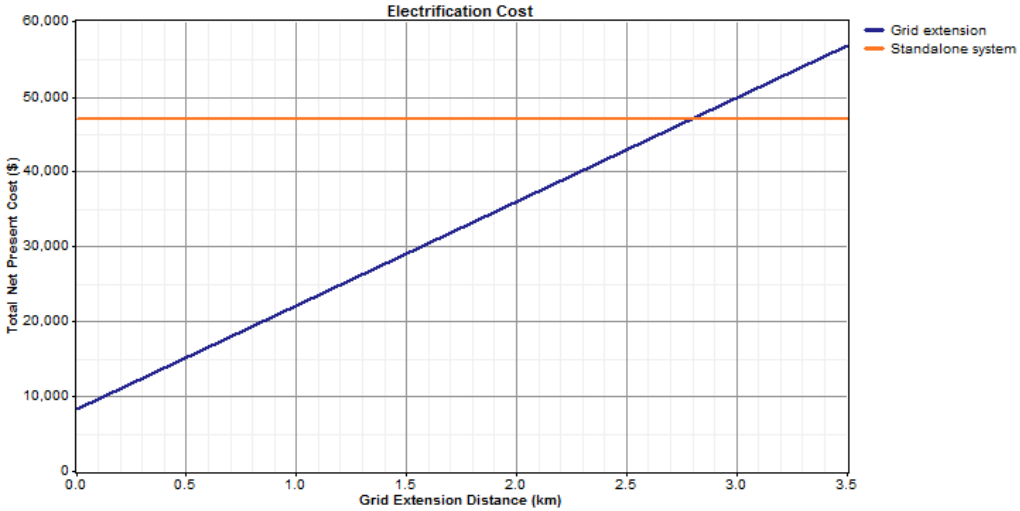
Business cases

Model: 1a

	0	1	2	3	4	5	6	7	8	9	10	Total
Existing Solution Net Cashflow	0	-15,256	-16,013	-36,495	-17,641	-18,517	-24,225	-35,302	-21,416	-27,269	-38,499	-250,632
Renewable Solution Net Cashflow	-62,700	-2,575	-2,575	-2,575	-2,575	-2,575	-14,575	-2,575	-2,575	-2,575	11,900	-85,975
Net Difference	-62,700	12,681	13,438	33,920	15,066	15,942	9,650	32,727	18,841	24,694	50,399	164,657
Total Existing Solution OPEX	0	15,256	16,013	36,495	17,641	18,517	24,225	35,302	21,416	27,269	38,499	250,632
Total Renewable Solution OPEX	0	2,575	2,575	2,575	2,575	2,575	14,575	2,575	2,575	2,575	-11,900	23,275
Average Existing Solution OPEX	25,063											
Average Renewable Solution OPEX	2,328											
OPEX Savings ($/yr)	22,736											

PayBack (years)	2.76
ROI	36%
IRR	32%
NPV	$41,051
Discount Rate	0.14

Grid extension break-even distance: 2.79 km



FINANCIAL

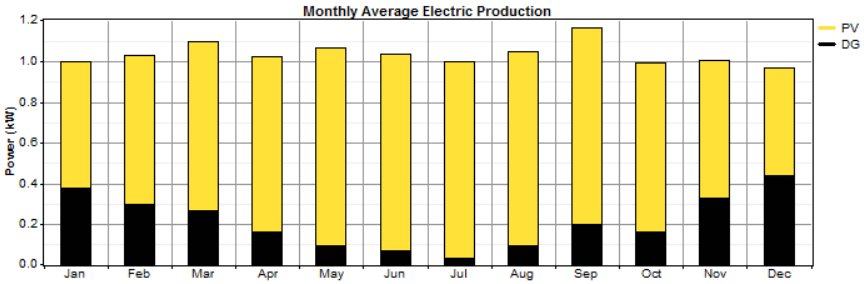
CAPEX	$62,700
Payback period (yr)	2.76
ROI	36%
IRR	32%
NPV	$41,051
Average OPEX Savings (per year)	$22,736

Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Design Models

Model: 1a_upg

1a (13 Sites)		
	Design Model	**1a**
	Homer Model Load	0.8 kW
Sites Considered	**ID sites**	13
	OD sites	0
	3G sites	0
	Fixed DG sites	13
Exisitng Load Considered	**BTS Load**	440-880W
	TxRx Load	110/177/370W
	3G Load	-
Additional Load Considered	**Battery Cooler**	-
	Aircon/Heater (@10hrs/day)	-
Power Scenario considered	**Generator**	15/20KVA
	Grid Status	Off-grid
	Avg. Daily DG Run	11.65 hrs
Site Availability & Revenue Loss	**Avg. site Availability**	99.90%
	Avg. Daily Voice Traffic Lost (Erl/Site)	0
	Avg. Daily Data Traffic Lost (MB/Site)	0
	Revenue Loss ($/Site/year)	0



DESIGN

Proposed System Architecture	
PV	5.76 kW (32 x 180W)
Wind	-
Generator	15 KVA (or Existing)
Controller	120 Amps
Battery @48V	1 x 600 Ah (OPzS or Equivalent)
Rectifier	6 kW
Inverter	6 kW

Renewable indicators	
Autonomy	25.20 hrs
Excess Electricity	14.60%
DG hours of Operation	312 hrs / yr
Renewable Generation	7,240 kWh / yr
Contribution to Energy	PV: 80%
	Wind: 0%
	DG: 20%

Environmental Indicators		
Diesel Solution CO2 Emission	25.30	Ton per site / yr
Renewable Solution CO2 Emission	1.71	Ton per site / yr
Reduce CO2 Emission of	23.59	Ton per site / yr

Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Business cases

Model: 1a_upg

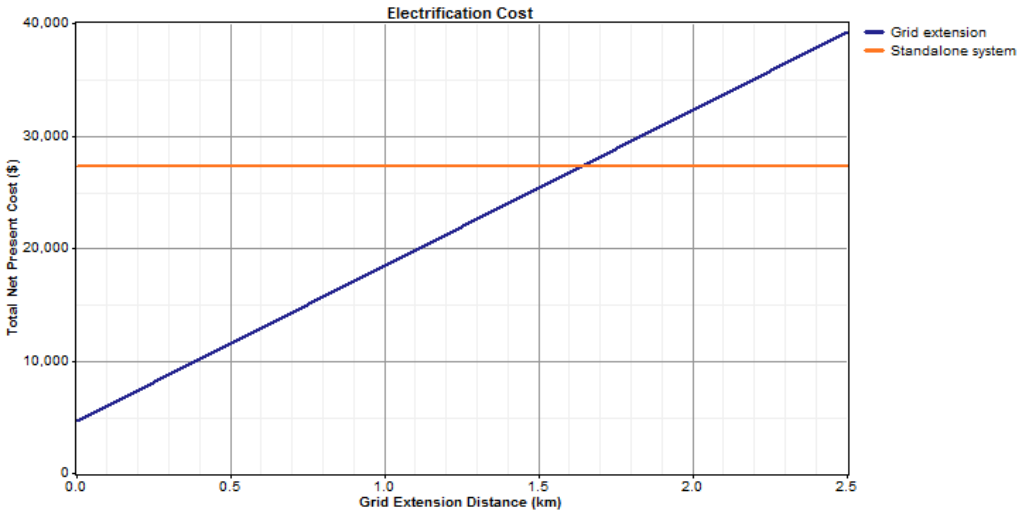
	0	1	2	3	4	5	6	7	8	9	10	Total
Existing Solution Net Cashflow	0	-15,256	-16,013	-36,495	-17,641	-18,517	-24,225	-35,302	-21,416	-27,269	-38,499	-250,632
Renewable Solution Net Cashflow	-43,350	-1,629	-1,629	-1,629	-1,629	-1,629	-7,629	-1,629	-1,629	-1,629	8,147	-55,864
Net Difference	-43,350	13,627	14,384	34,866	16,012	16,888	16,596	33,673	19,787	25,640	46,646	194,768
Total Existing Solution OPEX	0	15,256	16,013	36,495	17,641	18,517	24,225	35,302	21,416	27,269	38,499	250,632
Total Renewable Solution OPEX	0	1,629	1,629	1,629	1,629	1,629	7,629	1,629	1,629	1,629	-8,147	12,514
Average Existing Solution OPEX	25,063											
Average Renewable Solution OPEX	1,251											
OPEX Savings ($/yr)	23,812											

PayBack (years)	1.82
ROI	55%
IRR	46%
NPV	$63,839
Discount Rate	0.14

FINANCIAL

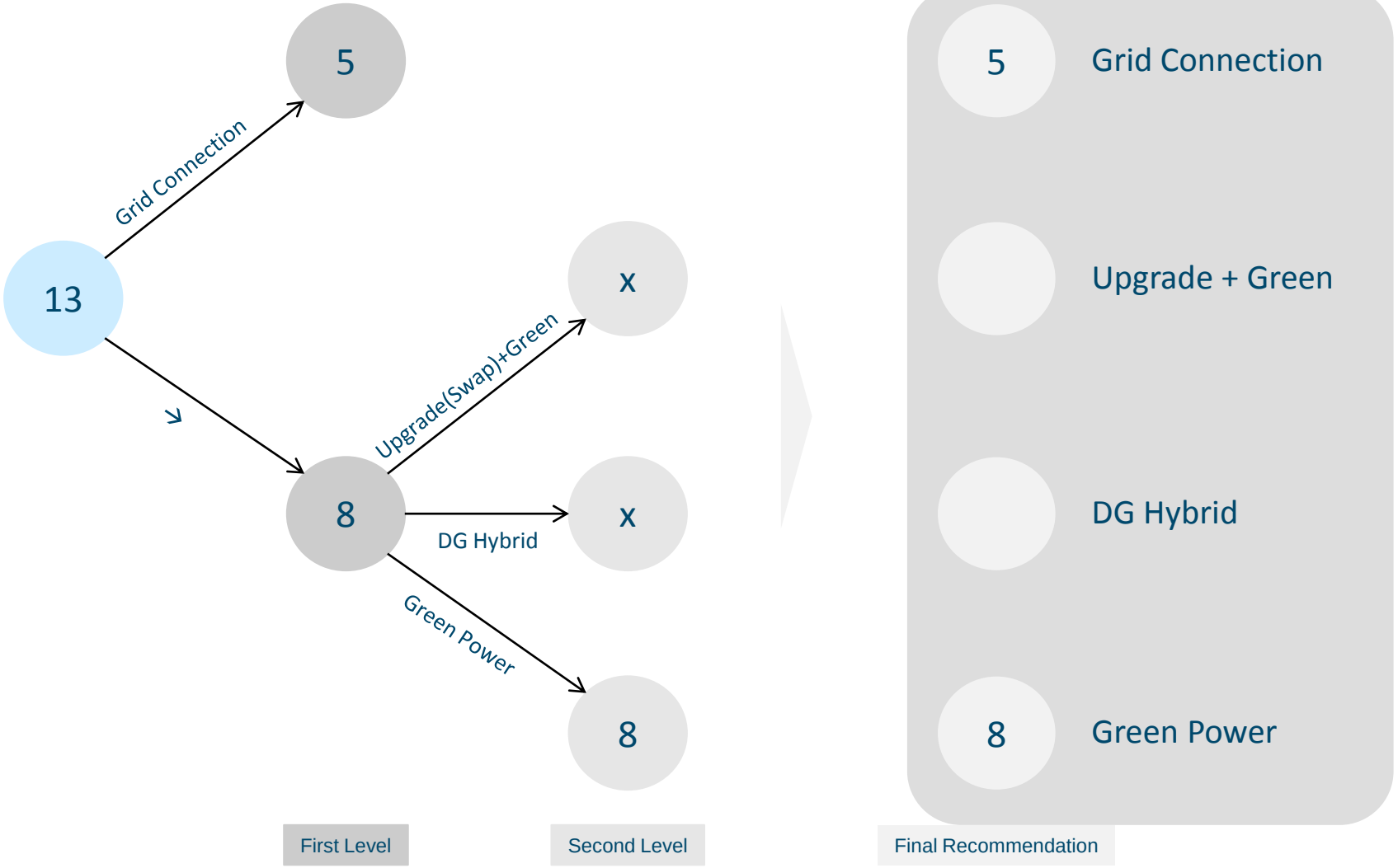
CAPEX	$43,350
Payback period (yr)	1.82
ROI	55%
IRR	46%
NPV	$63,839
Average OPEX Savings (per year)	$23,812

Grid extension break-even distance: 1.63 km



© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Analysis and Recommendations

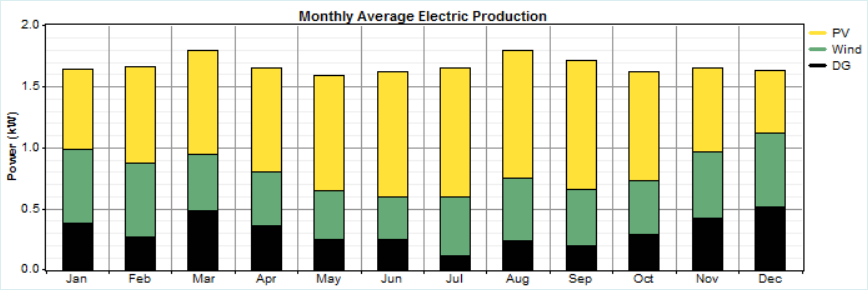


Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Design Models

Model: 1b

1b (7 Sites)		
	Design Model	**1b**
	Homer Model Load	0.8 kW
Sites Considered	**ID sites**	7
	OD sites	0
	3G sites	0
	Fixed DG sites	7
Exisitng Load Considered	**BTS Load**	440-880W
	TxRx Load	110/177W
	3G Load	-
Additional Load Considered	**Battery Cooler**	-
	Aircon/Heater (@10hrs/day)	1.5 kW
Power Scenario considered	**Generator**	15/20KVA
	Grid Status	Off-grid
	Avg. Daily DG Run	11.27 hrs
Site Availability & Revenue Loss	**Avg. site Availability**	100.00%
	Avg. Daily Voice Traffic Lost (Erl/Site)	0
	Avg. Daily Data Traffic Lost (MB/Site)	0
	Revenue Loss ($/Site/year)	0



DESIGN

Proposed System Architecture	
PV	5.76 kW (32 x 180W)
Wind	3.00 kW (1 x Kestrel e400i or Equivalent)
Generator	15 KVA (or Existing)
Controller	120 Amps
Battery @48V	2 x 600 Ah (OPzS or Equivalent)
Rectifier	8 kW
Inverter	8 kW

Renewable indicators	
Autonomy	28.30 hrs
Excess Electricity	5.55%
DG hours of Operation	312 hrs / yr
Renewable Generation	11,898 kWh / yr
Contribution to Energy	PV: 51%
	Wind: 30%
	DG: 19%

Environmental Indicators		
Diesel Solution CO2 Emission	24.47	Ton per site / yr
Renewable Solution CO2 Emission	1.93	Ton per site / yr
Reduce CO2 Emission of	22.54	Ton per site / yr

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Business cases

Model: 1b

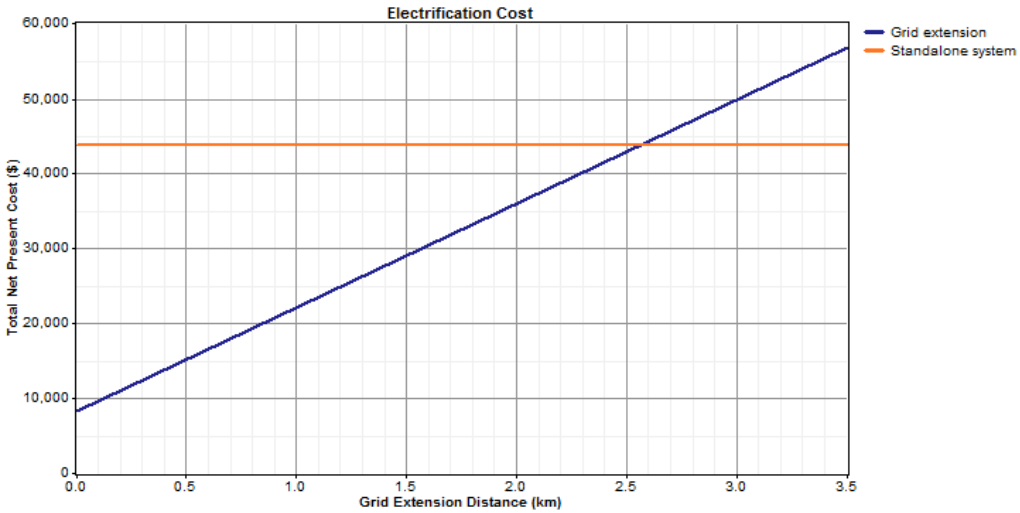
	0	1	2	3	4	5	6	7	8	9	10	Total
Existing Solution Net Cashflow	0	-15,256	-16,013	-36,495	-17,641	-18,517	-24,225	-35,302	-21,416	-27,269	-38,499	-250,632
Renewable Solution Net Cashflow	-75,080	-1,936	-1,936	-1,936	-1,936	-1,936	-13,936	-1,936	-1,936	-1,936	11,819	-92,685
Net Difference	-75,080	13,320	14,077	34,559	15,705	16,581	10,289	33,366	19,480	25,333	50,318	157,948
Total Existing Solution OPEX	0	15,256	16,013	36,495	17,641	18,517	24,225	35,302	21,416	27,269	38,499	250,632
Total Renewable Solution OPEX	0	1,936	1,936	1,936	1,936	1,936	13,936	1,936	1,936	1,936	-11,819	17,605
Average Existing Solution OPEX	25,063											
Average Renewable Solution OPEX	1,761											
OPEX Savings ($/yr)	23,303											

PayBack (years)	3.22
ROI	31%
IRR	28%
NPV	$32,960
Discount Rate	0.14

FINANCIAL

CAPEX	$75,080
Payback period (yr)	3.22
ROI	31%
IRR	28%
NPV	$32,960
Average OPEX Savings (per year)	$23,303

Grid extension break-even distance: 2.56 km

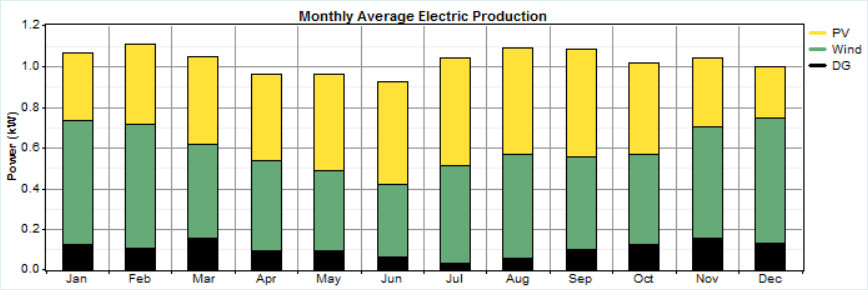


Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Design Models

Model: 1b_upg

1b (7 Sites)		
	Design Model	**1b**
	Homer Model Load	0.8 kW
Sites Considered	**ID sites**	7
	OD sites	0
	3G sites	0
	Fixed DG sites	7
Exisitng Load Considered	**BTS Load**	440-880W
	TxRx Load	110/177W
	3G Load	-
Additional Load Considered	**Battery Cooler**	-
	Aircon/Heater (@10hrs/day)	-
Power Scenario considered	**Generator**	15/20KVA
	Grid Status	Off-grid
	Avg. Daily DG Run	11.27 hrs
Site Availability & Revenue Loss	**Avg. site Availability**	100.00%
	Avg. Daily Voice Traffic Lost (Erl/Site)	0
	Avg. Daily Data Traffic Lost (MB/Site)	0
	Revenue Loss ($/Site/year)	0



DESIGN

Proposed System Architecture	
PV	2.88 kW (16 x 180W)
Wind	3.00 kW (1 x Kestrel e400i or Equivalent)
Generator	15 KVA (or Existing)
Controller	60 Amps
Battery @48V	1 x 600 Ah (OPzS or Equivalent)
Rectifier	6 kW
Inverter	6 kW

Renewable indicators	
Autonomy	25.20 hrs
Excess Electricity	16.70%
DG hours of Operation	156 hrs / yr
Renewable Generation	8,108 kWh / yr
Contribution to Energy	PV: 42%
	Wind: 48%
	DG: 10%

Environmental Indicators		
Diesel Solution CO2 Emission	24.47	Ton per site / yr
Renewable Solution CO2 Emission	0.85	Ton per site / yr
Reduce CO2 Emission of	23.62	Ton per site / yr

Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Business cases

Model: 1b_upg

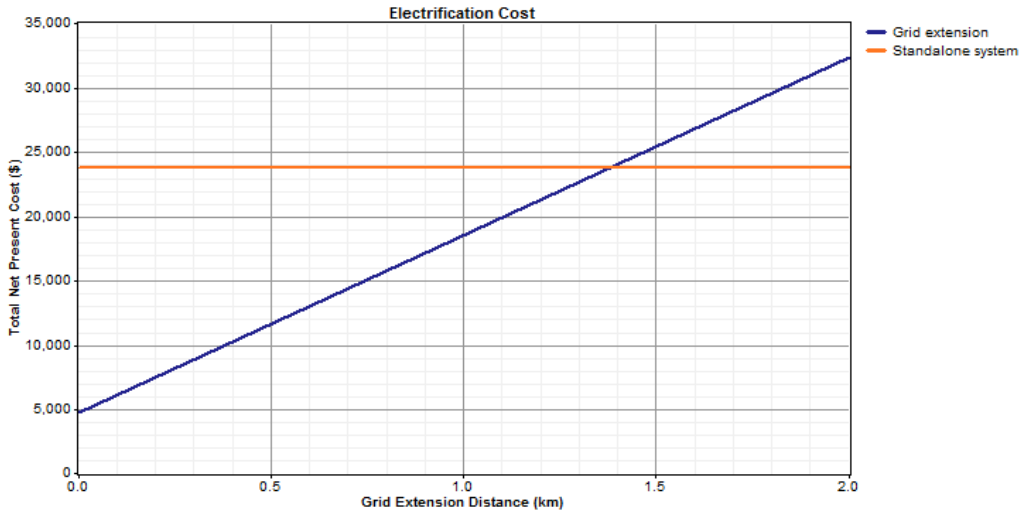
	0	1	2	3	4	5	6	7	8	9	10	Total
Existing Solution Net Cashflow	0	-15,256	-16,013	-36,495	-17,641	-18,517	-24,225	-35,302	-21,416	-27,269	-38,499	-250,632
Renewable Solution Net Cashflow	-55,729	-950	-950	-950	-950	-950	-6,950	-950	-950	-950	8,106	-62,173
Net Difference	-55,729	14,306	15,063	35,545	16,691	17,567	17,275	34,352	20,466	26,319	46,605	188,459
Total Existing Solution OPEX	0	15,256	16,013	36,495	17,641	18,517	24,225	35,302	21,416	27,269	38,499	250,632
Total Renewable Solution OPEX	0	950	950	950	950	950	6,950	950	950	950	-8,106	6,444
Average Existing Solution OPEX	25,063											
Average Renewable Solution OPEX	644											
OPEX Savings ($/yr)	24,419											

PayBack (years)	2.28
ROI	44%
IRR	38%
NPV	$55,936
Discount Rate	0.14

FINANCIAL

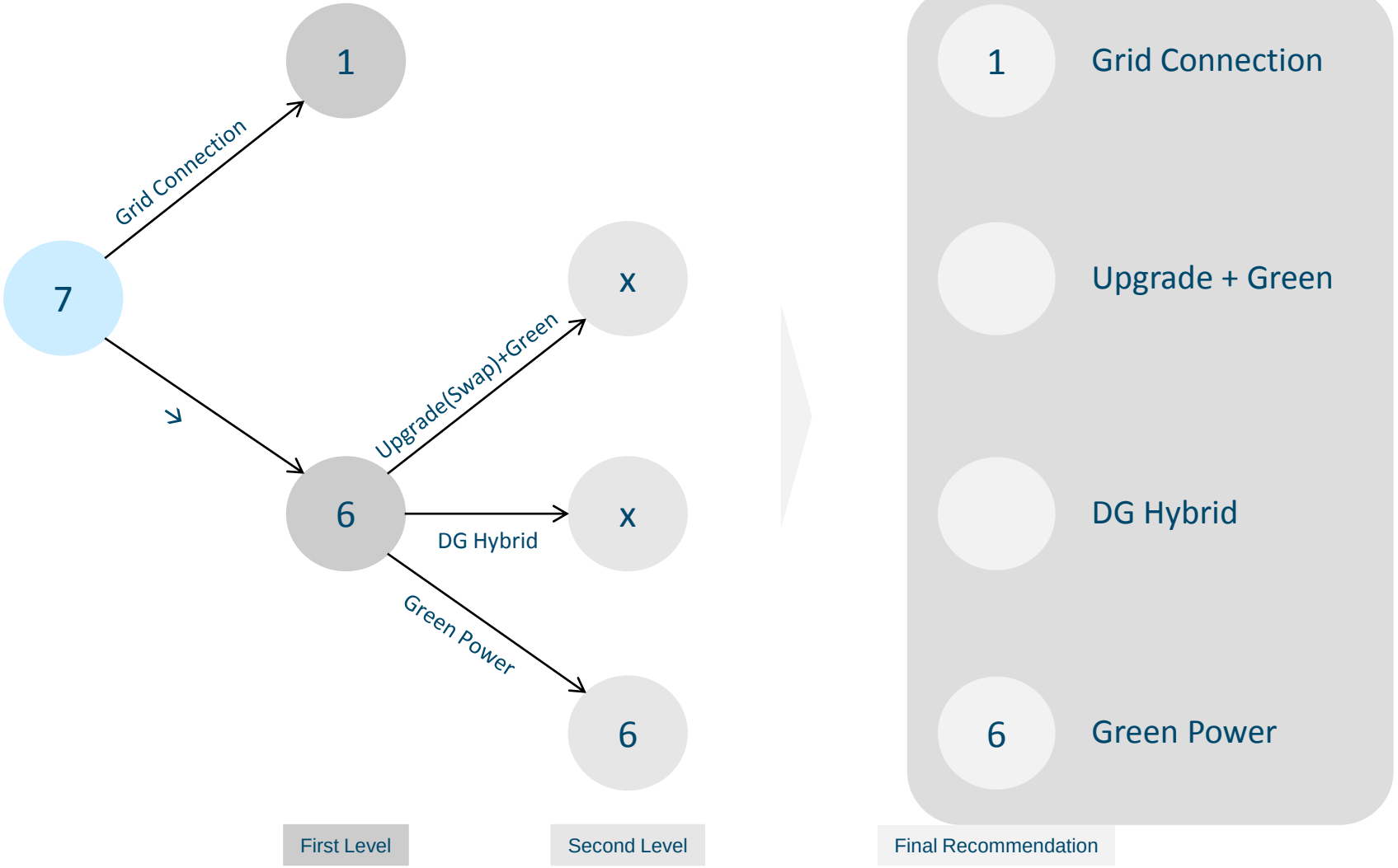
CAPEX	$55,729
Payback period (yr)	2.28
ROI	44%
IRR	38%
NPV	$55,936
Average OPEX Savings (per year)	$24,419

Grid extension break-even distance: 1.38 km



© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Analysis and Recommendations



© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Agenda

- Overall Network Data Analysis
- Overall Context Analysis
- Renewable Resource Analysis
- Design Modeling and Business Cases
- **Analysis and Recommendations**
- Prioritization and Financials
- Overall Summary

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Analysis and Recommendations: *Designs*

Design Model							Proposed Solution						
No. of Sites	Model	Model Load	Site Load Range	3G	Hub	3G & Hub	PV	Wind	Battery	DG	Controller	Converter	Land Requirement (Sq.m)
13	1a	0.8 kW	550-1030W	0	5	0	8.64 kW	-	2 x 800 Ah	15 KVA	180 A	8 kW	62.208
7	1b	0.8 kW	617-990W	0	0	0	5.76 kW	3.00 kW	2 x 600 Ah	15 KVA	120 A	8 kW	41.472
16	1cd	0.8 kW	397-1030W	0	3	0	5.04 kW	3.00 kW	2 x 600 Ah	15 KVA	125 A	8 kW	36.288
15	2a	1.3 kW	1057-1607W	0	0	0	9.36 kW	-	2 x 800 Ah	15 KVA	200 A	12 kW	67.392
11	2b	1.3 kW	1057-1612W	0	5	0	9.36 kW	3.00 kW	2 x 800 Ah	15 KVA	200 A	10 kW	67.392
17	2cd	1.3 kW	1057-1540W	2	5	0	5.04 kW	6.00 kW	2 x 600 Ah	15 KVA	125 A	8 kW	36.288
14	3ab	1.9 kW	1690-2023W	2	9	1	9.36 kW	6.00 kW	2 x 800 Ah	15 KVA	200 A	10 kW	67.392
6	3cd	1.9 kW	1690-2144W	2	6	2	6.48 kW	6.00 kW	2 x 800 Ah	15 KVA	150 A	12 kW	46.656
5	4ab	2.4 kW	2170-2562W	4	3	2	9.36 kW	6.00 kW	2 x 800 Ah	15 KVA	200 A	12 kW	67.392
6	4cd	2.4 kW	2382-2738W	4	4	3	7.92 kW	6.00 kW	2 x 800 Ah	15 KVA	150 A	12 kW	57.024
4	5abc	3.3 kW	3077-3597W	3	1	0	0.00 kW	0.00 kW	(Existing)	15 KVA	-	0 kW	0

Design Model		Renewable Indicators							Financial Indicators							
No. of Sites	Model	PV	Wind	DG	Battery Autonomy (Hrs)	DG Run (Hrs/yr)	Green Power (kWh/yr)	Excess electricity (%)	CAPEX ($)	OPEX ($/yr)	OPEX Saving ($/yr)	Payback period (Yrs)	ROI (%)	IRR (%)	NPV ($)	CO2 Emission Reduction (Ton)
13	1a	74%	0%	26%	28.30	446	10861	4.45%	62,700	2,328	22,736	2.76	36%	32%	41,051	22.54
7	1b	51%	30%	19%	28.30	312	11898	5.55%	75,080	1,761	23,303	3.22	31%	28%	32,960	22.54
16	1cd	43%	47%	10%	28.30	177	13754	10.80%	72,870	1,135	22,439	3.25	31%	28%	32,667	21.82
15	2a	60%	0%	40%	27.90	639	11639	2.04%	71,937	3,979	21,084	3.41	29%	26%	26,189	24.66
11	2b	60%	22%	18%	27.90	333	15975	4.85%	94,567	1,833	23,231	4.07	25%	22%	14,369	23.35
17	2cd	28%	63%	9%	20.90	230	20969	20.80%	84,750	1,166	23,898	3.55	28%	25%	27,404	25.42
14	3ab	45%	33%	22%	21.30	515	20205	6.22%	106,447	2,627	23,391	4.55	22%	19%	5,177	26.18
6	3cd	31%	54%	15%	21.30	321	22836	10.70%	96,529	1,980	21,593	4.47	22%	19%	4,607	20.78
5	4ab	37%	29%	34%	17.80	822	19752	3.13%	107,697	4,607	20,456	5.26	19%	15%	-11,077	19.53
6	4cd	33%	47%	20%	17.80	501	24705	7.61%	101,281	2,880	22,183	4.57	22%	19%	3,876	19.48
4	5abc	0%	0%	100%	-	4406	0	-	-	-	-	-	-	-	-	-

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Analysis and Recommendations: *Summary*

	Final Recommended Sites			
	Grid Extension	**Green Power**	**DG + Battery hybrid**	**Upgrade /Green**
	5	8	0	0
	1	6	0	0
	4	12	0	0
	4	5	5	1
	8	0	3	0
	6	6	2	3
	10	0	4	0
	3	0	3	0
	5	0	0	0
	4	0	2	0
	3	0	1	0
Total	53	37	20	4

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Agenda

- Overall Network Data Analysis
- Overall Context Analysis
- Renewable Resource Analysis
- Design Modeling and Business Cases
- Analysis and Recommendations
- **Prioritization and Financials**
- Overall Summary

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Prioritization and Financials: *Prioritization*

First Level Prioritization		
Levels (A,B,C,D)	# of Sites	Priority - (i)
*, *, L1, L1	27	1
*, *, L1, L2/3	23	2
*, *, -, L1	46	3
*, *, -, L2/3	18	4

Second Level Prioritization	
Levels	Priority - (ii)
Grid extension sites & Green with payback < 3yrs	1
Green with payback < 3.25 yrs	2
Green with payback > 3.25 yrs	3
DG hybrid sites	0

Final Priority		
(i), (ii)	# of Sites	Priority - (ii)
1, 1/2	19	1
2/3, 1/2	45	2
4, 1/2	15	3
*, 3	22	4
*, 0	13	NP

First Level Prioritization Matrix							
Prioritization		Range	L1	L2	L3	L4	L5
A	BH Traffic	0-312	>=50	<50, >=30	<30, >=15	<15, >=5	<5
B	Daily Traffic	0-4287	>=500	<500, >=250	<250, >=100	<100, >=25	<25
C	3G/Hub/Sub-Hub	All L1	L1				
D	Accessibility		Difficult	Moderate	Easy		

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Prioritization and Financials: *Summary*

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**	

Sites by Priority				
Priority	Grid	Green	DG	UPG/Green
1	13	6	0	0
2	29	16	0	0
3	11	4	0	0
4	0	11	7	4
NP	0	0	13	0
Total	**53**	**37**	**20**	**4**

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Prioritization and Financials: *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
Total	**41**							

Overall	No. of sites	CAPEX ($)	OPEX ($/yr)	OPEX Saving ($/yr)	Payback period (Yrs)	ROI (%)	IRR (%)	NPV ($)	
	41	73,680	1,882	22,745	3.24	31%	28%	32,243	Per Site
		3,020,886	77,159	932,552					Total

Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Agenda

- Overall Network Data Analysis
- Overall Context Analysis
- Renewable Resource Analysis
- Design Modeling and Business Cases
- Analysis and Recommendations
- Prioritization and Financials
- **Overall Summary**

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Overall Summary

Renewable solution recommended for	XXX Sites
Grid connection recommendations for	XXX Sites
DG + Battery hybrid recommended for	XXX Sites
Generic/Specific recommendations for	All Sites

CAPEX for green power deployment for recommended sites	$3.02M
OPEX based on Existing power-source for the recommended sites	$1.01M
OPEX after implementing renewable solution	$0.08M
OPEX Saving by Implementing Renewable Solution	$0.93M
Average ROI	31.0%
Average NPV	$32,243
Average IRR	28.0%
Average Payback Period	3.24 Yrs

After renewable solution implementation, CO2 Emission will be reduced by 954 Tons/year

© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy

Lets go Green

Thank you..!



Supported by the Netherlands



Restricted - Confidential Information
© GSMA 2012
All GSMA meetings are conducted in full compliance with the GSMA's anti-trust compliance policy