



## Green Power for Mobile

Supported by



# Azercell – Azerbaijan – Feasibility Study

In March 2011, Swedish telecom major TeliaSonera Eurasia signed an agreement with the GSMA for a Feasibility Study to be conducted by the Green Power for Mobile (GPM) team. The study encompassed technical and financial feasibility analyses on a large number of base stations in TeliaSonera's existing and planned networks in Nepal, Tajikistan and Azerbaijan, and identified those that are most suitable for green power solutions.

### Introduction

A Field Implementation Manager from GSMA's GPM Team was mobilised to each of the above operations where he stayed with each operation for about one month undergoing the information collection and analysis required to study their feasibility for renewable energy on both technical and financial grounds.

The entire projects duration spanned about 70 days, and its Primary Objective was to ensure that TeliaSonera maximises Return on Investment (ROI). Additional objectives of the project were:

- Provide recommendations on alternative energy technology, equipment sizes, new technologies, equipment trial possibilities, forecast CAPEX, forecast ROI & forecast NPV for base stations
- To support establishment of a centre of excellence within TeliaSonera through the provision of training materials and a training curriculum from GSMA Green Power for Mobile
- To assist with vendor identification and RFP (Request for Proposal) interpretations
- To provide a monitoring and evaluation framework (Key Performance Indicators) for assessing the technical and financial performance of the sites
- To provide TeliaSonera with a global platform from which to publicise its environmental

initiatives, through GSMA publicity materials/communication channels

- Introduce TeliaSonera to development banks including the International Finance Corporation (IFC – member of World Bank Group) to investigate financing options to support green power networks

In each of the three operations, a kick-off and close-out presentation was delivered to the technical team and senior management outlining the results of the analysis done. Moreover, an in-depth training on the technical simulation and financial analysis for renewable energy systems were delivered to multiple personnel within each operation.

At each of the operations, the following has been explored in detail to come up with a sound feasibility analysis for renewable implementation:

- Site technical information:
  - Power consumption, power plant, expansion plans
  - Outages, traffic volumes, operational pattern
  - Site layouts, connectivity
  - Equipment specifications and feedback on performance
- Equipment and service costing of existing service providers and system integrators
- Financial modelling information:
  - Interest rates, custom duties, insurance and transpo, etc.
  - Traffic patterns and call tariffs
- Logistical costs
- Meteorology office visit, NASA info, 3tier.com, GPM database

### About Azerbaijan

Azerbaijan is the largest country in the Caucasus region of Eurasia. Located at the crossroads of Western Asia and Eastern Europe, it is bound by the Caspian Sea to the east, Russia to the north, Georgia to the northwest, Armenia to the west, and Iran to the south. The exclave of Nakhchivan is bound by Armenia to the north and east, Iran to the south and west, while having a short borderline with Turkey to the northwest. Azerbaijan regained independence in 1991 from the Soviet Union. Shortly thereafter, during the Nagorno-Karabakh War, neighbouring Armenia occupied Nagorno-Karabakh, its surrounding territories and the enclaves of Karki, Yukhary Askipara, Barkhudarly and Sofulu. The Nagorno-Karabakh Republic, which emerged in Nagorno-Karabakh, continues to be not diplomatically recognized by any nation and the region is still considered a de jure part of Azerbaijan, despite being de facto independent since the end of the war. Baku is Azerbaijan's capital and largest city. Azerbaijan's area is 86,600 km<sup>2</sup> (33,436 sq mi) and has a population of about 9.1 million people. The GDP per capita is US\$7,914.

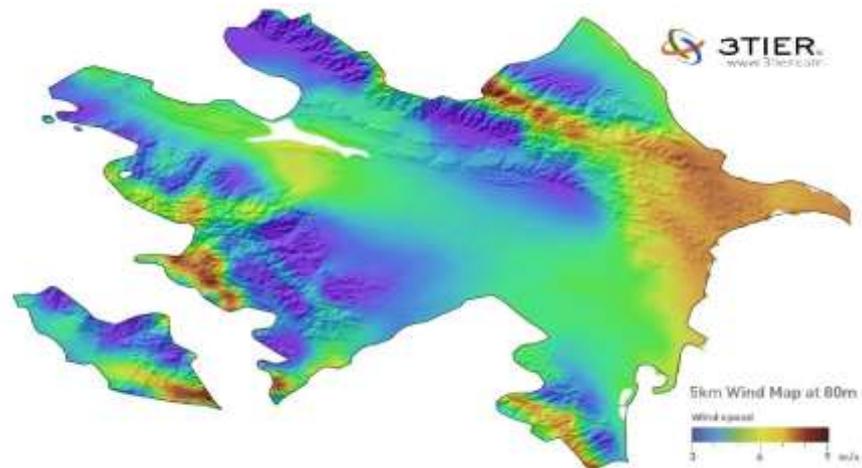
Azerbaijan's landscape is quite variant and has altitudes ranging from less than -500m below sea level to +4000m above sea level.





### Power Situation in Azerbaijan

Two thirds of Azerbaijan is rich in oil and natural gas. As Western oil companies are able to tap deepwater oilfields untouched by the Soviet exploitation, Azerbaijan is considered one of the most important spots in the world for oil exploration and development. Baku, the city's capital is considered to have 100% grid up-time, hence none of the base station sites in Baku have standby diesel generators. Baku is also known as “The Wind City”, as can be seen from the wind map below (right-most tip).



Though Azerbaijan has an abundance of oil and natural gas, the Minister of Environment and Natural Resources Huseyn Bagirov claims that in 8-10 years the amount of alternative energy produced in Azerbaijan will be the same as in developed countries.<sup>1</sup>

Indeed the government has started deploying wind farms in the city's capital and the plan is on-going to deploy more wind turbines to captivate energy from the sturdy winds.

Though the power is quite stable year-round in the capital and major cities, this is not the case in many towns and villages around the country. This is mainly due to the weak infrastructure of the power grid that fails during the winter season due to tough weather conditions – namely old transformers and corroded power poles. The government has taken measure to address this problem already and starting a couple of years ago they set a plan to strengthen the power infrastructure country-wide. Changes have already been realised by Azercell over the past year and the plan is on-going to more or less eliminate

<sup>1</sup> <http://news.day.az/economy/277509.html>

the country-wide power problems within the next 5-8 years<sup>2</sup>.

### **Azercell Network – In Brief**

LLC “Azercell Telecom” was established in 1996. Founders were Turkcell İletişim Hizmetleri A. S. and Ministry of Communications of Azerbaijan Republic. Azercell has a strong leading position in Azerbaijan and is the second largest operation within business area Eurasia. Azercell is operated through Fintur Holdings, with TeliaSonera owning 51.3%.

Fintur Holdings B.V. — is a partnership of Turkcell (42%) and TeliaSonera (58%). Fintur Holdings B.V. is one of the leading providers of mobile telecommunications services in the Eurasian emerging markets through its operations in Azerbaijan (Azercell), Kazakhstan (K-cell), Georgia (Geocell), Moldova (Moldcell) and Ukraine (Astelit).

### **Azercell – Challenges Faced**

- Determining current OPEX for existing sites – due to fixed bundled cost per site regardless of variable individual site OPEX incurred by subcontractor, in addition to no monthly records of DG running hours, or grid meter readings
- Determining cost of renewable equipment from local suppliers – due to availability to only one supplier in local market, and refusal to provide cost breakdown
- Delay in information collection – due to multiple versions of incomplete data provided by main contractor

### **Azercell Network Highlights**

Azercell, at the time of the feasibility study, had about 1800 operational base station sites, with almost 700 sites in the county’s capital Baku (hence excluded from the analysis as they have 100% grid up-time). About 800 of the remaining 1100 sites do not experience significant grid power outages and therefore do not justify the investment in alternative sources of energy for OPEX reduction. The remainder ~ 300 sites were further analysed and from them ~ 75 sites were in regions whereby the grid power reliability would drastically improve in the coming 2 years (based on feedback from Azercell Operations Team).

<sup>2</sup> [www.mie.gov.az/cgi-bin/min/main.cgi?id=749](http://www.mie.gov.az/cgi-bin/min/main.cgi?id=749)

### Approach to Financial Analysis & Site Modelling

The financial analysis or business case for renewable energy deployment in operational telecommunication networks aims at comparing Existing CAPEX & OPEX vs. Renewable CAPEX & OPEX. Azercell overall network availability is above 99.5%, therefore, one can interpret that nearly zero Erlangs of traffic are lost due to site outages; hence “lost revenue” does not play a role in the financial analysis. For networks with severe site outages – primarily due to power unavailability – the business cases for renewable deployment have to include a value for the lost revenue i.e. comparing Existing CAPEX & OPEX & Lost Revenue vs. Renewable CAPEX & OPEX.

Additionally, per site OPEX can only be generalised from Azercell’s perspective as Azercell incurs nearly the same costs of operation regardless of the site:

- per site, a fixed O&M cost per month is incurred regardless of whether or not the site has renewable implemented – hence was not filtered into business case
- per site with DG, an additional fixed O&M cost per month is incurred, regardless of DG running hours of that site. This cost will only be removed if the DG was dismantled from this site
- only battery replacement costs differ from one site to another as Azercell provides the batteries to the subcontractor for replacement

Ultimately, considering a project lifetime of 15 years and a discount rate of 8% (provided by the finance team at Azercell), the business cases did not yield a justifiable financial analysis for implementing renewable energy to existing operational sites.

Nonetheless, for new sites where there is no grid power available, going for renewable implementation is financially feasible and justifiable as proven by the business case below.

### Site Modelling

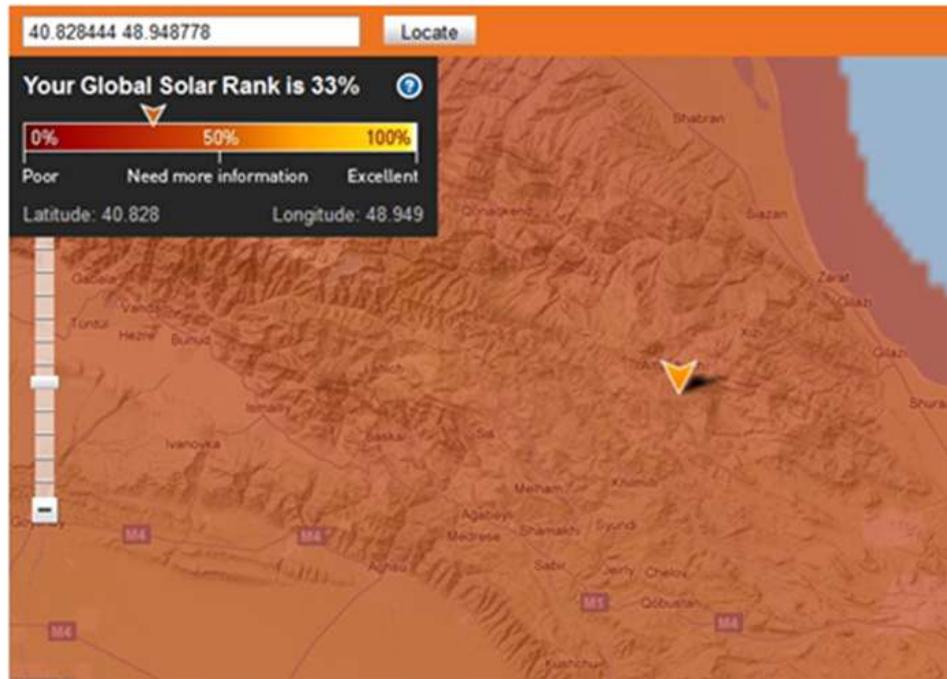
The technical modelling and business cases for a couple of sites in Azercell network were performed. Deducing from the Payback period and the ROI, the investment in renewable energy for existing operational sites is **not** justified.

#### Sample Results 1: Renewable for Existing Sites

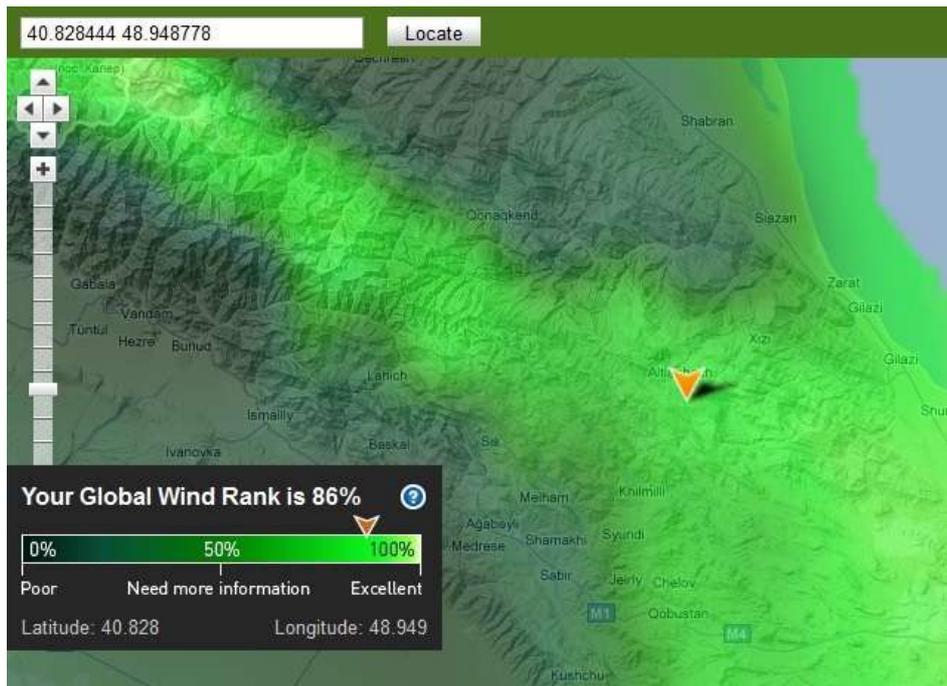
- Average Site Load: 650 W
- DG Status: N/A
- Grid Power: Connected with 10hrs average daily outage throughout the year

Proposed Architecture			Renewable Indicators		Financial Indicators			
Wind Turbine	Charge Controller	Batteries	Autonomy	Excess Electricity	Payback Period (yr)	ROI	IRR	CAPEX
1 X proven energy 7 - 2.5 kW @ hub height of 12m	1* 80A Outback FM80 MPPT controller	Trojan T-105 (6V): 225 Ahr AGM VRLA (2 strings) (-48 VDC operation)	56 hrs	71%	22.05 years	4.5%	-3.8%	US\$39,036

### Solar Rank



### Wind Rank

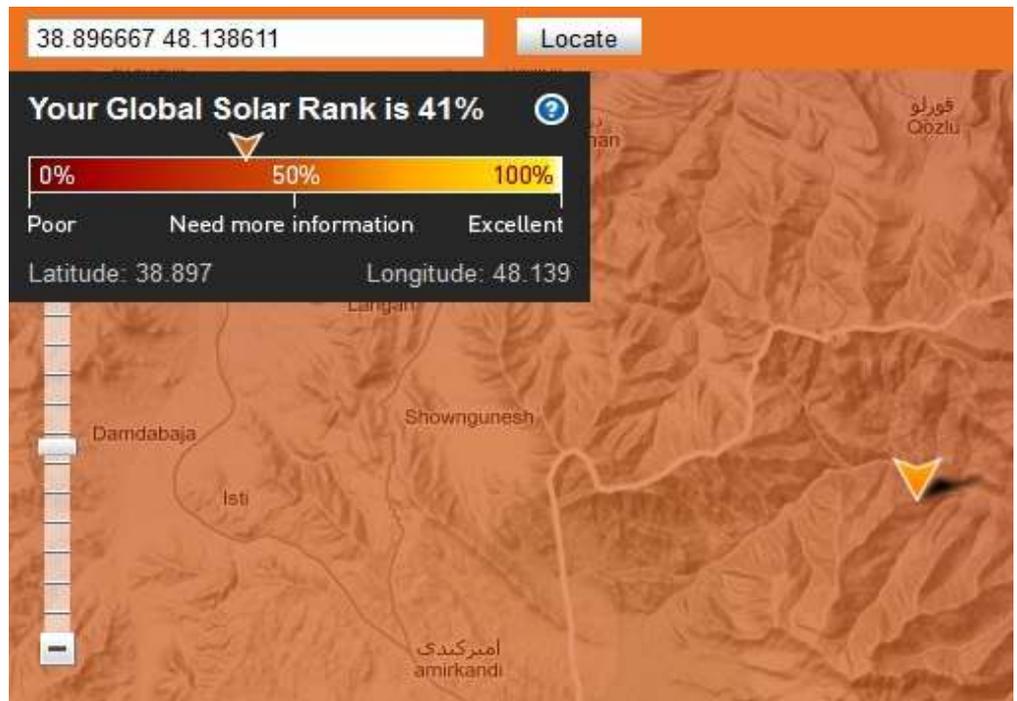


**Sample Results 2: Renewable for New Site (Off-Grid)**

- Average Site Load: 2,100 W
- DG Status: 22kVa
- Grid Power: Off-Grid

Proposed Architecture					Renewable Indicators			Financial Indicators				
Solar Power	Wind Turbine	Charge Controller	Batteries	Rectifier	Autonomy	Excess Electricity	Energy Contribution	Payback Period (yr)	ROI	IRR	CAPEX	NPV
7.2 kW - Trina TSM-DC01-180W (mono) OR Shoto RLD-180 (Sunleada)	2 X proven energy - 6.0 kW @ hub height of 18m	2* 80A outback FM80 MPPT controller	Hoppecke H-1000 (2V): 1000 Ahr OPzS (4 strings) (+24 VDC operation)	not needed (all DC system)	32 hrs	53%	Wind Turbine 76 %, Solar 24 %	3.99 years	25.1%	24.3%	US\$188,186	US\$162,839

**Solar Rank**



## Wind Rank



## Other Analyses Performed

### Free Cooling Unit Substituting Air Conditioners

Azercell has also realised the benefit of rolling-out outdoor sites as opposed to Indoor sites for reduction of power consumption, and will be going forward with future roll-outs mostly as outdoor sites.

Moreover, Azercell has trialled the use of Free Cooling Units in some of their indoor sites to replace/reduce the usage of the legacy AC air conditioners. When the business case was performed for such an investment, the results were quite positive, and the following were the financial indicators:

- Payback: 2.27 years
- ROI: 44.0%
- NPV: 40.0%
- CAPEX: 1000USD

### Existing Green Site Analysis

There is only one site in Azercell's operational network that is not connected to the grid and is powered completely with renewable energy. Nonetheless, the performance of this site was not satisfactory for Azercell operations team and technical management. Therefore, we made a full analysis of the history of this site, after an in-depth meeting with the system integrator that integrated the renewable solution on this site and we provided a detailed report to Azercell team with pointers on how to improve the performance of this site and what to take note of for future green sites.

### Planning for Future Off-Grid Sites

The following checklist needs to be followed during the planning stage for future off-grid sites:

- Determine coverage and capacity requirements
- Determine RBS equipment model with least power consumption
- Design power system to avoid multiple power conversions
- Identify suitable location for green site implementation
- May need to go back and revise step (b)

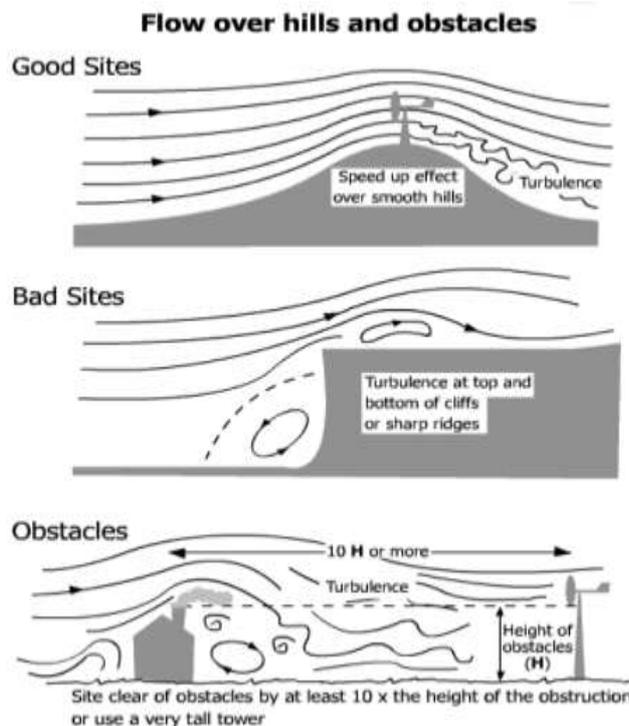
- Use NASA and 3tier data to dimension and perform initial design simulation
- Survey site location and terrain. In addition to obtaining information from local residents
- Use of anemometer to determine wind speeds over ~ 2 week period (e.g. Kestel, Lacrosse, Davis, E-bay) (that is only practical for large-scale roll-out of wind solutions)

#### Additional Pointers

- Use outdoor sites wherever possible to reduce OPEX by reducing energy bill and air condition maintenance.
- If indoor site is unavoidable, then use Free Cooling Units or DC air conditioners instead of Legacy AC air conditioning and insulation of shelters where applicable in addition to the use of battery coolers for indoor sites which will reduce heat in the room/shelter and will increase the battery life to almost double
- Implement auto-shutting of TRX (TCH) when not-used to reduce power consumption
- Avoid power conversions (AC-DC / DC-AC / DC-DC)
- Use of Deep Cycle Batteries on sites with high grid outages and green sites
- Orientation of solar panels in Azerbaijan must be towards south
- Tilt of solar panels is a function of Latitude - for latitudes ( $> 35^\circ$ ) tilt angle = latitude +  $15^\circ$ , rounded up to the nearest multiple of 5

#### Placing of Wind Turbines

Generally speaking, the higher the wind turbine, the better the wind speeds, the more the energy that can be harnessed and the more expensive the setup.



#### Battery Classification

Batteries can be classified by application (automotive, marine, deep cycle), or by construction (flooded, gelled – GEL, AGM – Absorbed Glass Material)

All GEL type batteries and most AGM batteries are VRLA (valve regulated lead acid).

Lifespan AGM deep cycle: 4-7 years Gelled deep cycle: 2-5 years Deep cycle (L-16 type etc.): 4-8 years

GEL - contains acid that has been "gelled" by the addition of Silica Gel, turning the acid into a solid mass that looks like gooey Jell-O:

- impossible to spill acid even if they are broken
- must be charged at a slower rate (C/20) to prevent excess gas from damaging the cells
- must be charged at a lower voltage (2/10th's less) than flooded or AGM batteries
- suitable for fully green site, with small inverter and charge controller

AGM - very fine fibre Boron-Silicate glass mat between plates “starved electrolyte”:

- has all the advantages of gelled, but can take much more abuse
- since all the electrolyte is contained in the glass mats, they cannot spill, even if broken
- since there is no liquid to freeze and expand, they are practically immune from freezing
- internal resistance is very low, i.e. almost no heating of the battery even under heavy charge and discharge currents
- have a very low self-discharge i.e. can sit in storage for much longer periods without charging than standard batteries

## Renewable Indicators and Pointers

### Solar

- Solar patterns do not vary much within a few square kilometres (except if shaded by building / large structure)
- Solar Insulation is low during the months where Grid power is unreliable Sept-Mar
- Solar Insulation is high during Apr-Sept (very good for sites not connected to Grid)

Monthly Averaged Insulation Incident On A Horizontal Surface (kWh/m2/day)												
Lat 41.2228 Lon 48.0642	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
22-year average	1.71	2.37	3.25	4.17	5.01	5.48	5.31	4.63	3.76	2.78	1.83	1.46

### Wind

- Wind patterns do vary incredibly within a few meters – especially due to the mountainous and hilly terrain
- Wind Speeds must be measured &/or surveyed prior to deploying Wind turbines for any site – as it may either be 100% beneficial or 100% loss if the location of the set-up was mistakenly chosen
- My recommendation is to go for wind turbine manufacturers that offer 5year warranty to avoid risk

Monthly Averaged Wind Speed at 50, 100, 150 and 300 m Above Earth's Surface (m/s)													
Vegetation Type: Rough glacial snow/ice													
Lat 41.2228 Lon 48.0642	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10 year average at 50m	7.43	7.92	7.47	7.00	6.48	7.08	7.53	7.44	7.01	7.14	7.63	7.72	7.43

## Overall Summary

Upon analysis of the entire network, the following summarizes the results that were outputted:

- Replace existing air conditions in indoor sites outside Baku with Free Cooling Units to reduce energy bill and OPEX from air conditioner maintenance.
- Install deep cycle batteries in sites with severe power outages and where currently batteries are replaced twice a year.
- Find alternate suppliers and system integrators for renewable energy
- Include power planning and OPEX consideration as an integral part of planning new sites that are off-grid and for future roll-out.

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### 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](mailto:greenpower@gsm.org)