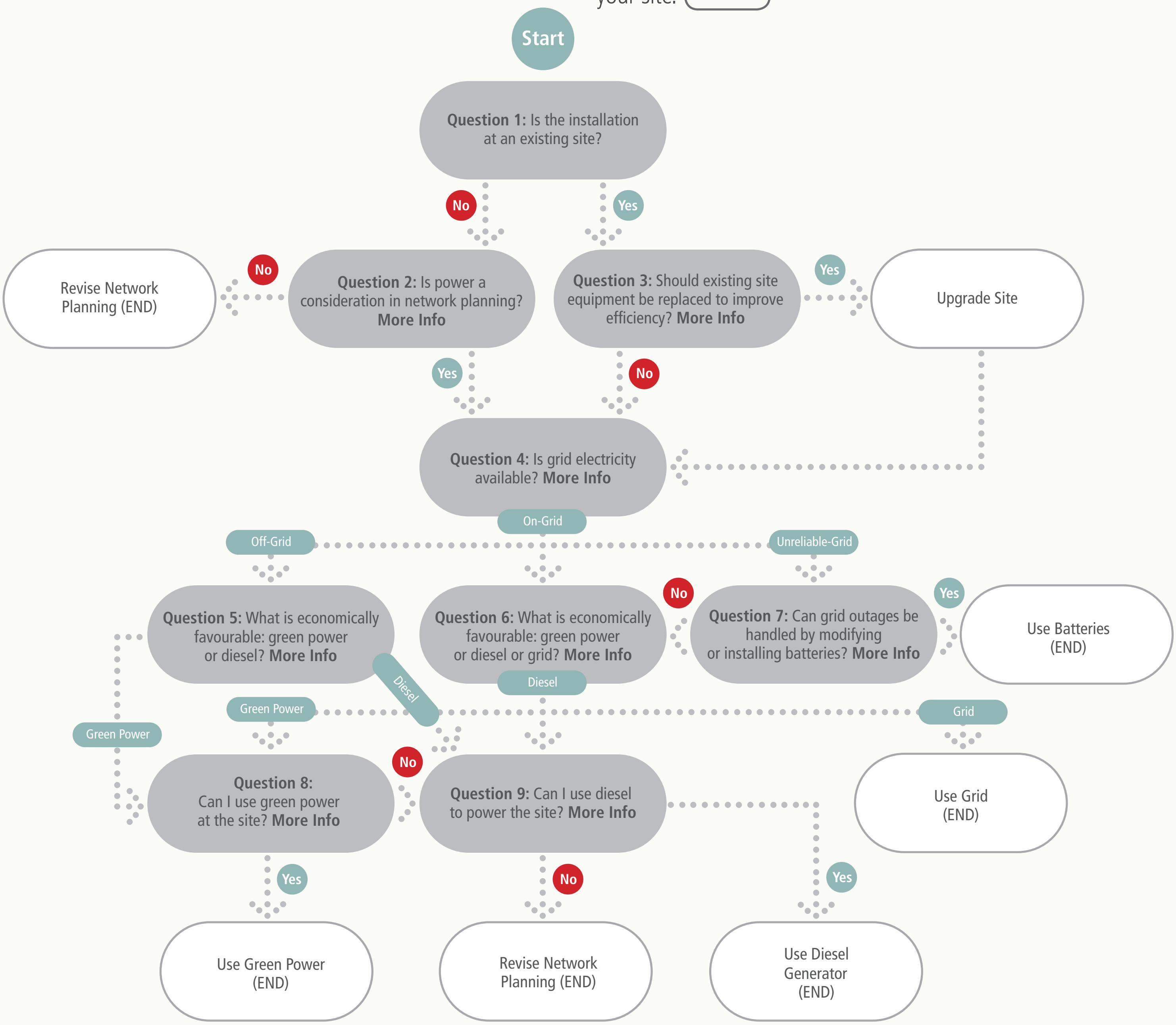
GSMA Green Power for Mobile

Green Power for Mobile Interactive Replication Guide

This Guide is intended to assist Mobile Network Operators navigate through the decision making process of determining if a site is a suitable candidate for renewable energy deployment.

This guide should not be read as a linear document. It has been designed as a decision tree, where the reader makes a series of choices Yes / No based upon reading information sheets accessed by clicking on the grey boxes. To return to this page click the Tree button. The guide ends by providing you with the appropriate solution for your site. Use batteries



Question 1: Is the installation an existing site?

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Yes

No

Question 2: Is power a consideration in Network Planning?

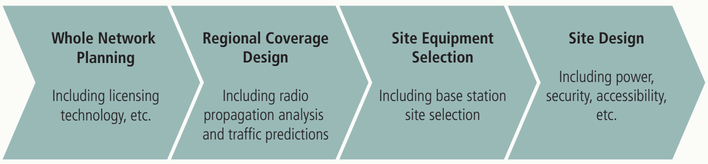
In order to answer the question of whether power is a consideration in network planning, it is useful to examine what site location considerations need to be made during the process. What site location considerations need to be made during network planning?

Key Points:

1. Power supply needs to be key consideration in the network planning and site locating process.
2. Green power solutions have particular impacts on possible site locations.

Network Planning Process

Traditional Network Planning Process



Base station site locations are typically selected to optimise network coverage during the network planning process. Responsibility for network design and base station site planning varies by operator and country, but power is often not considered until the site specific design stage, leading to problems with power supply.

If power supply is considered earlier, sites may be more optimally located closer to the electricity grid, in locations more accessible for fuel delivery, and where green power resources are more plentiful (e.g. windier, nearby hydro-resources, shade).

Site location and equipment selection have a significant impact on green power CAPEX. If green power is a serious option for powering all or part of a greenfield rollout, it is recommended that a power expert is involved in the network planning process.

Site Location Considerations

When site locations are defined during the network planning process there are specific considerations particular to green power solutions:

- The site location must be suitable for use of green power. For example, free from obstructions such as trees which can cause shade and/or wind drag.
- The site size must be adequate to accommodate the large footprint required for solar arrays.
- Ease of access is required to allow installation and maintenance.

Tree Yes No

Question 3: Should the existing site equipment be replaced to improve energy efficiency?

In order to answer the question of whether existing site equipment should be replaced to improve energy efficiency; it is useful to evaluate the power requirements of the existing site, current equipment compatibility with green power, and the options to upgrade current equipment and the economic viability of doing this.

Are the power requirements of the current site too high to use green power?

Key Points:

1. Old base station sites have higher power consumption.
2. The Internal Rate of Return for green power solutions is higher for modern, energy efficient sites.

Changes in Power Consumption

Energy use in mobile telecoms has only recently become a focus for network operators and equipment providers. However, new technologies and base station designs have been introduced to reduce the power consumption of base station sites.

The most substantial change in recent years has been the removal of air conditioning. New, more robust electronics in telecoms equipment prevents the need for tightly regulated climate control. In some climates cooling is still required to maintain battery life, however significantly smaller (lower power load) systems can be used.

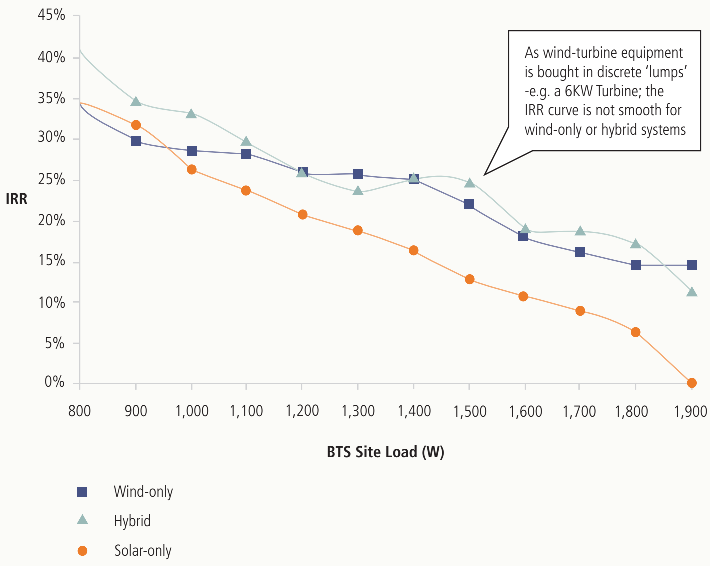
The power consumption of telecoms equipment at a base station sites has also reduced by every year since 2005. As such, old sites typically have less efficient equipment and therefore have higher power consumption. These sites require larger specification green power solutions, which will involve higher CAPEX.

Payback of Green Power versus Generators

A diesel-only solution will generally be based on an over-provisioned diesel generator (typically >10kVA).

As the generator is generally much larger than the load, the capital expenditure tends to be largely independent of site power consumption. Furthermore, fuel use for most generators of this size (10kVA) does not vary significantly for loads less than half of the rated power. As a result the payback time of green power relative to a generator solution is longer for less power-efficient sites. The deployment of green power provides on average (solutions are extremely scenario-sensitive) compelling returns on investment, particularly at lower loads.

Base Station Site Load versus IRR (relative to diesel generator)



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By reducing the amount of energy used at the base station site, the financial viability of green power increases substantially. See additional information on the economic attractiveness of upgrading old equipment to improve energy efficiency of the base station site.

Is it economically favourable to replace existing equipment?

Key Points:

1. There is a strong business case for replacing existing equipment and diesel generators.
2. Replacements costs must be below $24k for a 3 year payback.

Changes in Power Consumption

Replacing existing equipment, but retaining a diesel generator as the power solution, offers a potential business case for more established operators. By replacing old, energy inefficient equipment, the load requirements of the base station site are reduced and a more appropriately sized generator can be installed.

Larger AC generators use more fuel than smaller AC generators and for maintenance and functionality reasons, it is common for generators to be over-specified. Our interviews showed it is common to use 11-30kVA generators for a 5kW base station site. As the load on a generator decreases, the fuel consumption does not change significantly.

Using the latest equipment the following loads can be reduced:

1. **Cooling** 2kW cooling load entirely removed in many climates. In high-temperature climates a much smaller, equipment specific and/or non-compressor cooling method can be used – at approximately 200W.
2. **Base Station Equipment** more robust (to prevent need for cooling) and reduction from 1.2kW to 1kW. With remote radio heads this could be reduced further.
3. **Other** reduction of other loads from 300W to 100W.

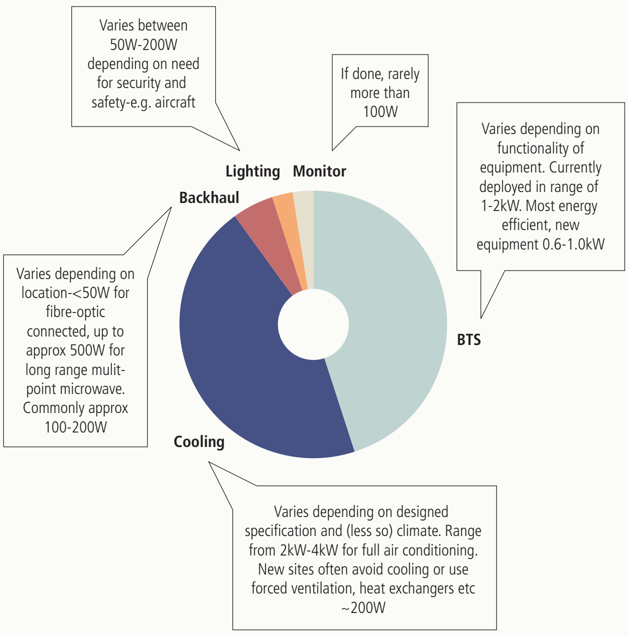
What are the options to upgrade current equipment?

Key Points:

1. Base station site power consumption is primarily from the base station equipment, active cooling, backhaul, lighting & monitoring.
2. There are numerous approaches to reducing power consumption.
3. Removal of active cooling and the use of remote radio heads allow significant reduction in base station site power consumption.

Site Power Consumption

A typical base station site has a number of contributors to its total power consumption as illustrated in the following graph.



Source: Interviews with vendors and operators
(Note: Figures vary considerably depending on site, climate, equipment etc)

Cooling
Cooling is a major contributor to power consumption at a base station site and can range between 2-4kW.

Cooling Telecoms Equipment
In the past, telecoms equipment providers specified operating temperatures up to 25°C, whereas 45°C is now typical for modern equipment. In hotter climates, maintaining 25°C requires active cooling, meaning large cooling loads. At 45°C, active cooling is not required providing that enclosures allow, or force (with a low power fan) airflow and are in the shade.

Cooling Batteries
Batteries are adversely affected by temperatures above 20°C. Battery temperatures rise much slower than the air in the enclosure. Therefore providing the daily average temperature (including night time) does not exceed 25°C, active cooling is not required. New battery technologies are expected to be more robust in high-temperature environments.

Design Suggestions
In order to prevent overheating, enclosures must be designed to allow passive cooling and sometimes require forced airflow. Design suggestions include:

1. Batteries are often installed in separate/external cabinets, allowing good airflow.
2. Enclosures and equipment are often installed in the shade below solar panels.
3. For situations where the batteries still require cooling, small battery-specific cooling can be used (200W battery specific cooling, vs. 2kW air conditioning system for whole enclosure).

Base Transceiver Station (BTS)
Energy efficiency has only recently appeared on the design agenda for a number of network equipment providers. Gradual reductions in power consumption have occurred through component improvement. Substantial reductions in power consumption can occur through the use of Remote Radio Heads and Standby Modes.

Remote Radio Heads
Substantial reductions in BTS power draw could occur through the adoption of Remote Radio Heads. Typically half the emitted power from radio transmitters is lost in the feeders due to cables being several tens of metres long. This can be minimised by limiting the distance between radio units and antennas.

The reduced power consumption and remote location of Remote Radio Heads has further advantages: it is much easier to cool passively, thus eliminating the BTS cooling load. In a typical small site (e.g. a 2/2/2) the power draw is now split between 4 cabinets; a baseband unit at the foot of the mast, and three physically separated Remote Radio Heads at the mast top. None of these units generates sufficient heat to require active cooling. Power savings from the elimination of active cooling are in addition to the savings realised by the masthead location of the remote radio heads.

Standby Modes
Intelligent low-traffic Standby Modes greatly reduce power consumption during off-peak times. BTS sites are dimensioned to cope with peak hours; during quieter periods standby mode could be used with no impact on service quality. This method can save approximately 20% of daily power load.

Backhaul
Power required for backhaul varies depending on the site's location and the method used. The most common method for off-grid rural BTS backhaul is terrestrial point-to-point microwave radio-relay, with a range from 50-500W depending on distance and number of points connected. Reductions could be made by changing the high-level network plan. A fibre-connected site consumes very small amounts of power (< 50W). Alternative methods for backhaul include satellite-microwave, WiMax and copper wire (ADSL), which are less commonly used.

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Lighting & Ancillary Equipment

Sites can also have a wide range of ancillary equipment. These highly variable loads are not important when using grid-electricity or an oversized diesel generator. However for a CAPEX-minimised green power solution it can be significant and therefore the use/installation of these items of equipment should be carefully considered.

Ancillary equipment includes:

1. Tower-top aircraft warning systems/mast-lights.
2. Flood lighting systems for security.
3. Ancillary lighting for equipment maintenance (low power CF or LED lights can reduce this load).
4. Spare electrical sockets for maintenance equipment (often abused – e.g. kettles/heaters).

Monitoring

Operators can monitor the sites for power usage in order to address problems with generation and loads. Previously monitoring of power consumption was a low priority due to the use of grid-electricity or oversized generators. With movement to a CAPEX-minimised green power solution, which is affected by the weather, monitoring of power use will become more important.

Is the current equipment compatible with green power?

Key Point:

1. Key equipment may need upgrading / modifying to be compatible with green power solutions.

If the installation is at an existing site the green power solution may affect the operation of the current equipment and certain considerations need to be made. Below is a list of equipment that could be affected by a green power solution installation and also any particular considerations:

Battery – A green power solution will require additional batteries to be installed. Batteries should be specified based on the specific wind and solar conditions, site power consumption and autonomy (i.e. power system failure) requirements. The key to a robust green power solution lies in the selection and sizing of batteries. For a site without a backup diesel generator, the battery may be the only power source during night-time and/or non-windy parts of the day and therefore is a critical component. Batteries suited to green power solutions, for example a daily charge/discharge for solar applications, have much longer life-times (up to 8 years) than general purpose batteries (1-2 years).

Diesel Generator – Installation of a green power solution will reduce the load requirements of the diesel generator. It may be required to switch to a smaller, more efficient (at smaller loads) diesel generator that is more suited to operate as a backup rather than 24/7.

Enclosure – The enclosure may need to be enlarged to accommodate additional batteries and control equipment. In order to reduce the cooling load, an alternative enclosure can be used which allows for passive and/or forced ventilation.

Power Inverters – Due to the substantial change to the size and type of batteries and therefore the requirement to convert power, any inverter currently installed will probably need to be replaced with one more suited to the green power solution.

Power Controllers – The existing generator controller cannot be re-used for green power. Both solar and wind power controllers should be designed specifically to suit the combination of panels/turbines, weather and battery size. A well designed controller will increase the amount of power captured during sunny/windy days and drastically increase battery life. When using a 'hybrid' configuration with more than one source of energy (e.g. solar + wind, wind + generator etc.), the design of a controller becomes even more important.

Power inverters – Battery strings provide a DC power source, whereas generators provide an AC power source. Rather than upgrade the inverter, it is far more energy efficient to run the site directly on DC power, removing the need for a DC – AC inverter and an AC-DC rectifier.

Tree < Yes No

Question 4: Is grid electricity available?

In order to answer the question of whether grid electricity is available, it is useful to explore the benefits of using the grid, if it is reliable, and whether it is possible to install a grid connection on site.

a. Off-grid
b. On-grid
c. Unreliable grid

What are the benefits of using the grid?

Key Points:

1. If available, grid electricity is typically preferable to using diesel or green power solutions.

If grid electricity is available and not too expensive, it should be used as the primary source of power for the base station site. Using grid electricity has a number of benefits over diesel and green power solutions:

- Lower CAPEX than green power solutions (see further grid CAPEX information)
- Lower OPEX than diesel generators (see further grid OPEX information)
- Minimal maintenance required
- Ease of scalability of site to higher power consumption
- Typically lower emissions than using diesel generators

Is it possible to install a grid connection on site?

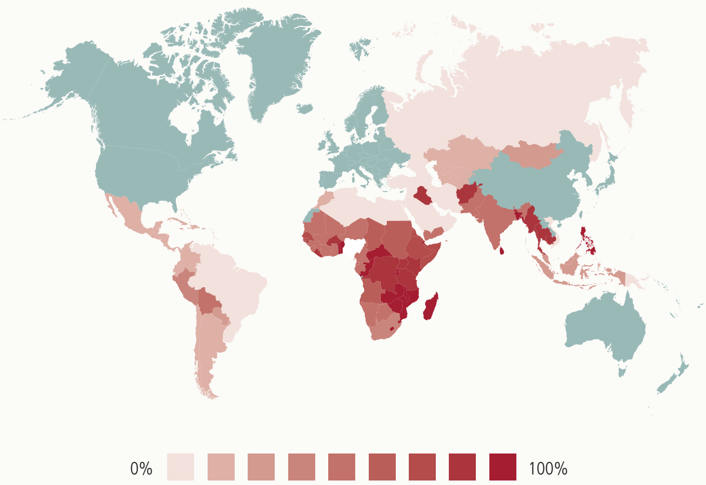
Key Points:

1. Grid availability can be an issue in the developing world
2. Distance to the grid and local terrain affect the economic viability of a grid connection
3. Grid connection lead times can be between 6-12 months

Grid Availability

The availability of grid electricity varies dramatically between countries. Grid availability is lower in the developing world than the developed world. In some countries in Africa, grid penetration as a percentage of population covered, is as low as 6% or 7% (UNDP Human Development Report).

Population Living Off-Grid



Distance and Terrain Limitations

The cost of a grid connection varies considerably (see further grid CAPEX information) for each country and is impacted by distance of the base station site to the grid and the terrain over which the connection is to be made. Some base station site locations will be unsuitable for a grid connection, such as mountainous regions.

Grid Connection Lead Times

Even if a grid connection is possible and affordable, lead times may be a barrier to network expansion plans. Operators have stated grid connection lead times between 6-12 months are typical.

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Is the grid reliable?

Key Point:

In many countries, the electricity grid is highly unreliable, therefore backup power solutions required.

Unreliable Grid Electricity

In the developed world the electricity grid is typically very reliable with power outages (blackouts) occurring only rarely. In the developing world the grid is far less reliable and power outages are frequent. Grid outages need to be covered by some form of backup, either with diesel generators, batteries or green power solutions.

Examples of Grid Unreliability in the Developing World

Region	Grid Availability
Nigeria	Available 15-25% of the time
Bangladesh	Urban: 4x 1hr outages /day Rural: 2x 4hr outages / day
Sri Lanka	Outages every day
India	10 hours power / day
Sumatra	4 hours outage / day
Pakistan	3,000-6,000 MW electricity capacity shortage
East Africa	Power outages 1 day a week; 4 hour rolling outages

Source: Operator interviews

Impact on Network Performance

If grid power supply to a base station site fails and there is no backup source available, the base station will not function and network availability will be affected.

Remote off-grid sites can sometimes be part of a network 'daisy-chain'. In this scenario it is vital that backhaul operation continues in order to route network traffic to the remaining links in the chain. As the backhaul requires significantly less power than the full base station site, power loads can be reduced by allowing the backhaul to operate while turning off the rest of the BTS.

This form of intelligent switching is not recommended as part of the planning for the regular power load / discharge cycle as removing coverage is likely to breach operators' licence conditions. However, the technology is extremely useful when designing a network for resilience to unpredictable power disruptions (e.g. extreme weather). Intelligent switching technologies minimise the battery size required, with consequent CAPEX reduction.

Future developments in intelligent switching may allow transceivers to power down based on the energy available and battery level. Operators must consider the most appropriate balance of coverage and capacity in order to optimise profit from their network.

Future Trends in Grid Availability

In most developing countries, grid coverage is increasing as economic development and infrastructure moves from cities to rural areas. However, in some regions of the world this extended coverage can be coupled with reduced reliability. Excess demand can lead to electricity grids introducing 'load-shedding', whereby power is rationed to particular areas of the country in order to prevent general 'brown-outs'.

South Africa's recent energy shortage has led to reduced electricity exports which have affected countries throughout Southern Africa. Symptoms include increased electricity prices and reduced reliability.

In Asia, some operators said that "telecoms is not a priority sector" for the electricity grid, and therefore operators may have difficulty connecting to or drawing reliable power from the grid.

Question 5: What is economically favourable: Green Power or Diesel?

In order to determine the most economically favourable power option it is useful to analyse the CAPEX and OPEX of the different options available – green power, diesel, and where relevant, grid.

The following pages provide information that will help you to answer these key questions:

- What is the CAPEX for green power technology? Click for more info
- What is the OPEX for the green power technology? Click for more info
- What tools can I use to check financial & technical viability? Click for more info
- Where do I get data regarding solar & wind resource availability? Click for more info
- What are the CAPEX & OPEX to install a diesel generator on the site? Click for more info
- What are the CAPEX & OPEX for a grid connection to the site? (relevant only if grid available) Click for more info

Question 6: What is economically favourable: Green Power, Diesel or Grid?

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Question 7: Can grid outages be handled by modifying/installing batteries?

In order to answer the question of whether grid outages can be handled by modifying / installing batteries, it is useful to examine what types of battery can be used and what length of outages they can handle.

What types of battery can be used?

Key Points:

1. There are many types of battery available each with specific advantages.
2. Open wet-cell batteries are suitable for easily accessed sites.
3. Flow batteries are a new technology, which maintain long lifetimes regardless of charging regime, but are currently significantly more expensive than lead-acid batteries.

Battery Requirements

Batteries are a key component of off-grid and unreliable grid power solutions. They are also used in combination with green power solutions.

Widely available lead-acid 'car' batteries are inappropriate for base station site-backup as they are designed to provide large bursts of energy. Instead, base station site systems require a battery that can withstand multiple charges and discharges over extended periods.

When using a green power solution, battery type is even more important as different battery designs suit different power cycles. For example, because solar modules generate energy gradually during the day and use the stored energy overnight (i.e. cycle every 24 hours), batteries need to be designed to cycle a large number of times.

Types of Battery Technology

Different types of battery technology to be considered are Open Lead-Acid Wet-Cell; Absorbed Lead-Acid (or "Gel") and Flow batteries. Each of these technologies has a number of different materials and specifications, which depending on the manufacturer may be more or less suitable to green power applications.

Batteries are rated at 25ºC. Above this temperature, the lifetime of the battery decreases significantly. A battery maintained at 35ºC will have 50% of the rated life. This applies to all lead-acid batteries. Flow batteries are designed to operate up to 40ºC. Above this temperature, the battery will temporarily stop working. Therefore it is very important to carefully control the environment of all battery types.

What length of outages can the battery handle?

Key Points:

1. For grid outages of less than eight hours a day, batteries alone may be a suitable solution.
2. Repeated cycling of batteries can shorten battery lifetime.

Grid Outages

In the developing world the grid can be unreliable with frequent outages (See further information on grid unreliability). This impacts the reliability of the base station site and the network coverage it provides.

Traditionally outages are covered by diesel generators or batteries. Batteries are preferable to diesel generators as they do not need fuel to be kept on site, there are no emissions or noise, and they are easier to maintain. Similarly to green power solutions, batteries have high CAPEX but low OPEX as there is no diesel cost.

For grid outages of less than eight hours a day, batteries alone may be a suitable solution.

Impact of Battery Cycling

Lead-acid battery lifetime is determined by the number of 'cycles' through which the battery is charged and discharged. Longer and deeper cycles mean heavily reduced lifetimes. As such, when an unreliable grid is supported by battery backup, the optimum battery size can be difficult to calculate.

Furthermore, lead-acid batteries require consistent (and often slow) charging regimes in order to re-establish a full charge. Therefore in some situations, adding a wind or solar generator to ensure batteries are not deep-discharged and are re-charged consistently, can greatly increase battery life and reduce operating costs.

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Battery Comparison Table

	Maintenance	Lifetime	Controller	Cost
Open Lead-Acid Wet-Cell	**Requires maintenance** Top up with distilled water approximately every 3 months	**Long life** Up to 2000 cycles for 80% rated capacity Could last 15-20 years Life reduces dramatically with temperature	**Needs good charge controller** To limit gassing, stratification, and sulphurisation	**Low Cost** <US$ 100-200/kWh
Absorbed Lead-Acid (Gel)	**Maintenance free** Batteries are sealed	**Shorter life than wet-cells** Up to 1600 cycles for 80% rated capacity Could last 10-15 years Life reduces dramatically with temperature	**Less susceptible to charging problems**	**Mid priced** US$ 150-200/kWh
Flow Batteries	**Low maintenance** Some maintenance may be required for fluid pumping system	**Lifetime guaranteed for 10 years** Not cycle dependent Will not operate above 40°C	**Integrated controllers manage charge/ discharge** To limit gassing, stratification, and sulphurisation	**Expensive** ~US$ 1,000/kWh Cost reducing rapidly

Tree < Yes No

Question 8: Can I use green power at the site?

Can I use green power at the site?

In order to answer the question of whether you can use green power at the site, it is useful to explore the availability, price trends and import barriers for green power solutions, as well as how you would select a solution provider and considerations around theft, maintenance and possible site sharing.

The following pages provide information that will help you to answer these key questions:

- How do I select a green power solution provider? Click for more info
- Can you protect against theft & vandalism? Click for more info
- Can the green power equipment be maintained? Click for more info
- What are the availability and price trends for green power technology? Click for more info
- Is site sharing with other operators an option? Click for more info

Tree Yes No

Question 9: Can I use diesel to power the site?

In order to answer the question of whether you can use diesel to power the site, it is useful to determine whether you can get diesel to the site, as well as to understand the risk of theft and the maintenance requirements.

Is it possible to get diesel to the site?

Key Points:

1. Availability of diesel varies regionally.
2. Distribution of diesel is dependent on transportation infrastructure and site location.

Availability of Diesel

Diesel is a refined fuel and requires transportation from production sites to consumption locations. Most locations covered by telecommunications operators are able to source diesel. However, cost is highly variable depending on transportation. Many locations in the developing world suffer an unreliable supply of diesel due to supply chain problems and seasonal restrictions to accessibility.

Logistical Limitations of Delivering Diesel to a Site
Diesel consumption varies greatly based on the utility of diesel generators as a power source. For remote sites relying exclusively on generators, typical fuel consumption for a base station generator (<=15kVA) is approximately 1,500Litres/month. As such, generators require frequent and large deliveries of fuel. There are several factors affecting delivery logistics:

- **Road access to site**
  Site accessibility by road and distance to a fuel depot determine the ability to deliver diesel by conventional means (lorry). In sparse populations (e.g. Namibia) the distance from depot to site makes fuel distribution costs prohibitively high.
- **Alternative methods of transportation**
  Remote locations lacking road access (such as islands or mountain locations) require alternative means of transportation. These locations are often serviced by boat or aircraft. Fuel distribution to island and mountain sites in Vanuatu requires distribution by helicopter. In extreme cases manual transportation (cart) has also been noted. Each of these methods limits the quantity of fuel that may be distributed in each visit and substantially increases cost.
- **Cost of distribution**
  Fuel distribution can either be managed internally by operators or through an outsourced distributor. Most operators outsource to a fuel delivery company. Distribution costs are material and result in a substantial premium to regional 'pump' prices. In extreme cases the cost of distribution is greater than the price of diesel itself.
- **Security**
  Diesel distribution vehicles are attractive targets for theft. Theft can occur internally within the distributor or externally in transit. Operators estimate that on average, 10% of fuel costs are a result of theft, with the figure rising to 50% in extreme cases.
- **Safety**
  The risk is further amplified by poor road quality and high risk methods of transportation (as above). The risk of lost deliveries must be considered in fuel delivery and onsite storage.

Seasonal Variability on Diesel Availability

Heavy seasonal weather such as monsoon seasons in Southeast Asia and snowfall in mountainous regions can severely restrict the supply of diesel to base station sites. This leads to increased distribution costs and reduced reliability of the base station site.

Operators have cited that in some cases nearly 80% of aggregate network down-time is the result of diesel shortages at sites. Shortages are due to a number of factors including fuel availability and theft, but are amplified by seasonal variability in fuel supply.

What is the risk of theft of fuel and generator?

Key Points:

1. Diesel theft is a significant problem in developing regions.
2. Generator theft can also occur.

Diesel Theft

Operators in developing regions are routinely affected by theft in their network fuel supply chains. Theft and tampering can occur at multiple points in the supply chain:

- Operationally by external distributors (tampering of fuel or incorrect book-keeping)
- Loss during transit
- From site after distribution

Operators estimate that on average, 10% of fuel costs are a result of theft, with the figure rising to 50% in extreme cases.

Many operators have instituted various security measures to reduce fuel theft (as well as equipment theft and vandalism) including physical structures (walls, fencing) and 24 hour security, but it is almost impossible to eliminate. The problem is only likely to increase with rising diesel prices.

Generator Theft

Generators used for telecommunications sites are large (typically 7kVA – 15kVA) and are deployed in heavy metal or concrete housing. Heavy lift equipment is required for the deployment of generators, but this does not always prevent theft in some problematic regions.

What are the maintenance requirements for diesel generators?

Key Points:

1. Diesel generators in constant use require mechanic visits every ~10 days, which is a substantial cost.
2. The more isolated a site the higher the maintenance cost will be.

Maintenance Requirements

Diesel generators require regular engine maintenance including parts servicing and routine oil changes. Generator oil samples are also routinely collected to assess the health of individual site generators and forecast replacement requirements.

Generators require servicing at 250 hour runtime intervals. For sites relying entirely on generators for power, this represents a requirement for physical site access approximately every 10 days. For extremely remote sites or low accessibility sites this can constitute a significant cost beyond routine maintenance costs, which are typically in excess of US$200 per service for regular sites.

Maintenance Costs

Maintenance costs include the cost of replacement parts and the cost of a mechanic's time to carry out the replacement. Where as parts can be treated as a fixed cost, the cost of the mechanic's time depends on many factors such as distance travelled to sites, hourly labour rate, and the skill of the mechanic.

Scheduled Maintenance

Scheduled maintenance depends on how long the generator has been in service. In the early stages, fuel and air filters need replacing and oil levels need to be checked. In mid life, the generator will require an oil change and injector pumps and injection nozzles may need cleaning or replacing. At the end of life, maintenance requirements increase significantly, with major parts needing to be replaced.

Generators operating 24 hours / day will require replacement or complete overhaul approximately every 18 months.

Fuel and Oil Quality

The quality of the fuel and oil used can have a significant effect on the life of the generator. When fuel quality is low, filters, pumps and injector nozzles need replacing more frequently. In these cases, it may be worth considering treating fuel with additives to improve the quality, but this is generally only feasible where fuel can be stored and treated in bulk.

Tree Yes No

What is the CAPEX for green power technology?

Key Points:

1. Green power CAPEX is formed from equipment costs, battery & controller costs & additional civil works.
2. Solar solutions work best for small loads due to the CAPEX increasing with load requirements.
3. Wind solutions have a lower CAPEX than solar solutions and are particularly suitable for high load requirements.
4. Batteries can represent a significant part of the overall CAPEX.
5. Combined solutions (e.g. wind and solar) can be the most cost effective, as they increase the reliability of power generation by combining independent power sources, thus reducing required battery capacity.

Elements of Green Power CAPEX

Green power solutions typically have higher CAPEX than diesel generators. The CAPEX is formed from 3 key elements: green power equipment (e.g. solar panels, turbines & generators), batteries/controllers, and additional civil works.

Green Power Equipment

Green power equipment, such as solar panels and wind turbines, is costly in comparison to generators. Solar panels are expensive. Their cost is effectively linear to load requirements and therefore is very expensive for high load requirements. Wind turbine costs scale at a lower than linear rate. Wind is therefore more cost effective than solar at higher load requirements.

Batteries & Controllers

To provide sufficient backup for periods when green power equipment is not able to generate electricity, for example dark or still days, battery backup is required, which can form a large component of CAPEX – particularly at higher loads. The required battery load will also depend on the expected duty cycle of the batteries: solar arrays are a more reliable source of energy than wind turbines as some power will be generated even on overcast days, whereas wind turbines generate no power until a start-up wind speed (typically 5m/s) is reached. Wind turbines therefore generally require larger battery banks than solar arrays. In many scenarios, combined wind and solar power systems provide the most cost effective solution.

In the calculations of batteries and control-gear in the tables below batteries are conservatively specified to provide 3 days autonomy. Significant savings can be made on this cost if lower autonomy is required from the batteries.

To control the energy-generation equipment and to ensure maximum power output, sophisticated controller mechanisms are required, which carry an additional cost.

Additional Civil Works

Green power solutions can have a large area footprint at the site and this carries an additional CAPEX cost for civil works. Solar solutions, due to their large area requirements have very high civil works costs for high load sites.

Examples of Green Power CAPEX

The following CAPEX examples are for different sites, each one being meteorologically suitable for the solution (i.e. there is significant solar and wind resource).

Solar CAPEX

The solar solution works best for small loads due to CAPEX increasing with load, while generator CAPEX hardly increases (due to over-sizing).

CAPEX on a Hypothetical Solar Solution Base Station Site in Uganda

BTS Site Load		1,000W		2,000W		3,000W	
Location – Uganda		Diesel	Solar	Diesel	Solar	Diesel	Solar
Capital Expenditure		US$'000s					
	Solar Panels & Generator	18	59.7	18	105	27	150.4
	Batteries and Control-gear	0	26.5	0	41.9	0	57.2
	Additional Civil Works	0	12	0	12	0	12
	Total	**18**	**98.2**	**18**	**158.9**	**27**	**219**

Source: Uganda Green Power Evaluation Tool (GPET) site analysis

The wind solution has a lower CAPEX than the solar solution and is more suited to high load requirements.

CAPEX on a Hypothetical Wind Solution Base Station Site in Northern India

BTS Site Load		1,000W		2,000W		3,000W	
Location – N. India		Diesel	Wind	Diesel	Wind	Diesel	Wind
Capital Expenditure		US$'000s					
	Wind Turbine & Generator	18	39.4	18	39.4	27	N/A
	Batteries and Control-gear	0	35	0	50.4	0	N/A
	Additional Civil Works	0	12	0	12	0	N/A
	Total	**18**	**86.4**	**18**	**101.8**	**27**	**N/A**

Source: Northern India Green Power Evaluation Tool (GPET) site analysis

Tree

Hybrid CAPEX

The hybrid solution gives a strong combination of the benefits of wind and solar technologies. At high load requirements CAPEX is not as high as for the solar only solution. The use of solar in the solution reduces the impact of the particular issues with a wind only solution (see GPM point of view on wind solutions).

CAPEX on a Hypothetical Wind / Solar Solution Base Station Site in Somalia

BTS Site Load		1,000W		2,000W		3,000W	
Location – Somalia		**Diesel**	**Hybrid**	**Diesel**	**Hybrid**	**Diesel**	**Hybrid**
Capital Expenditure		**US$'000s**					
	Solar Panels, Turbine & Generator	18	45.1	18	76.8	27	95.5
	Batteries and Control-gear	0	35	0	50.4	0	65.7
	Additional Civil Works	0	12	0	12	0	12
	Total	**18**	**92.1**	**18**	**139.2**	**27**	**173.2**

Source: Somalia Green Power Evaluation Tool (GPET) site analysis

Future Trends in Green Power CAPEX

See further information on future trends in green power availability and cost.

Tree < To Q.5 < To Q.6

What is the OPEX for green power technology?

Key Points:

1. Green power solutions can have substantially lower OPEX than diesel generators.
2. The key elements of green power OPEX are fuel costs, green power maintenance / replacement & battery maintenance / replacement.

Green Power OPEX

Green power solutions can have substantially lower OPEX than diesel generators. Generators have high OPEX from fuel and maintenance costs. Green power solutions have very low OPEX formed from 3 key elements: maintenance/replacement costs and battery maintenance/replacement and where used, fuel costs for a backup generator.

Elements of Green Power OPEX

Diesel Costs

If the green power solution requires no backup generator because batteries provide sufficient reliability, the fuel costs will be zero. Some green power solutions will require a small generator as additional backup. However, if green power equipment is well specified, the renewable resource remains consistent, and batteries are suitably dimensioned, then diesel consumption should be minimal. See further information on diesel OPEX.

Green Power Generator Maintenance & Replacement Costs

Green power solutions have minimal maintenance costs (see further information on maintenance). Also, due to the long lifespan of green power solutions there are minimal replacement costs.

Battery Maintenance / Replacement Costs

Green power solutions require significant battery capacity to provide power when green power technology is not able to produce enough electricity, for example on still or cloudy days. Battery maintenance costs are a small contribution to green power OPEX, but battery replacement costs are significant due to the comparatively (compared with the green power equipment) short lifespan of batteries. If batteries are poorly maintained or mis-used their lifespan will shorten and green power OPEX will increase.

Examples of Green Power OPEX

The payback period for green power solutions is highly dependant on diesel price, which is demonstrated in the graphs below. See further information on green power solutions payback periods.

Solar OPEX

At a diesel cost of US$ 1.2/Litre the solar solution pays back the additional CAPEX in approximately three years for a site in Uganda. With high diesel costs at US$ 2.4/Litre, the solar-only system pays back in 18 months.

OPEX on a Hypothetical Solar Solution Base Station Site in Uganda

BTS Site Load		**1,000W**		**2,000W**		**3,000W**	
Location – Uganda		**Diesel**	**Solar**	**Diesel**	**Solar**	**Diesel**	**Solar**
Capital Expenditure		**US$'000s**					
	Fuel (at US$1.2/L delivered cost)	23.1	0.18	23.1	0.18	27	0.24
	Panel/Generator Maint. & Replacement	8.4	6.6	8.4	6.6	8.4	7.75
	Battery Maintenance & Replacement	0	2.9	0	5.9	0	6.45
	Total	**31.5**	**11.3**	**31.5**	**12.7**	**35.4**	**14.4**

Source: Uganda Green Power Evaluation Tool (GPET) site analysis

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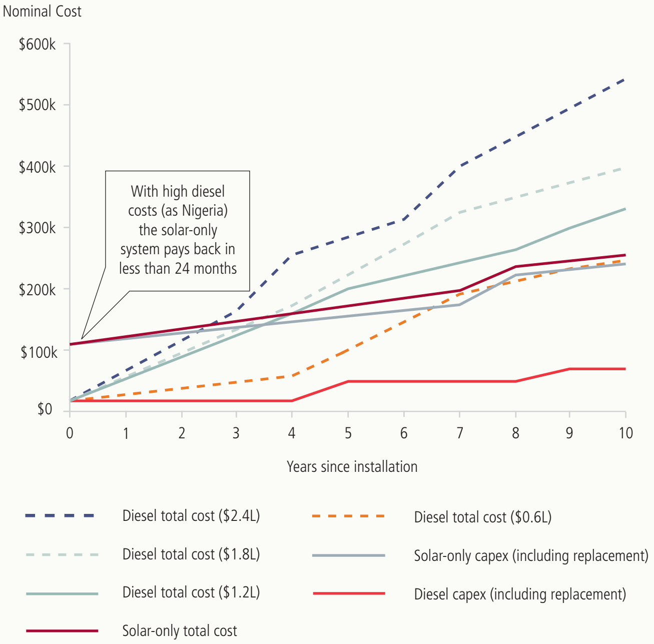
Pay Back Period for a Hypothetical Solar Solution Base Station Site in Uganda



Source: Uganda Green Power Evaluation Tool (GPET) site analysis

Wind OPEX

At a diesel cost of US$ 1.2/Litre the wind solution pays back the additional CAPEX in roughly 2.5 years for a site in Northern India. With high diesel costs at US$ 2.4/Litre, the wind-only system could pay back in approximately 12 months.

OPEX on a Hypothetical Wind Solution Base Station Site in Northern India

BTS Site Load		1,000W		2,000W		3,000W	
Location – N. India		**Diesel**	**Wind**	**Diesel**	**Wind**	**Diesel**	**Wind**
Capital Expenditure		**US$'000s**					
	Fuel (at US$1.2/L delivered cost)	23.1	1.2	23.1	0.18	27	N/A
	Turbine/Generator Maint. & Replacement	8.4	4.43	8.4	6.6	8.4	N/A
	Battery Maintenance & Replacement	0.0	2.94	0.0	5.9	0.0	N/A
	Total	**31.5**	**7.55**	**31.5**	**12.7**	**35.4**	**N/A**

Source: Uganda Green Power Evaluation Tool (GPET) site analysis

Tree

Pay Back Period for a Hypothetical Wind Solution Base Station Site in Northern India

Source: Northern India Green Power Evaluation Tool (GPET) site analysis

Hybrid Solar/Wind OPEX

At a diesel cost of US$ 1.2/Litre the hybrid solar/wind solution pays back the additional CAPEX in less than 2.75 years for a site in Somalia. With high diesel costs at US$ 2.4/Litre, the hybrid system could pay back in approximately 24 months.

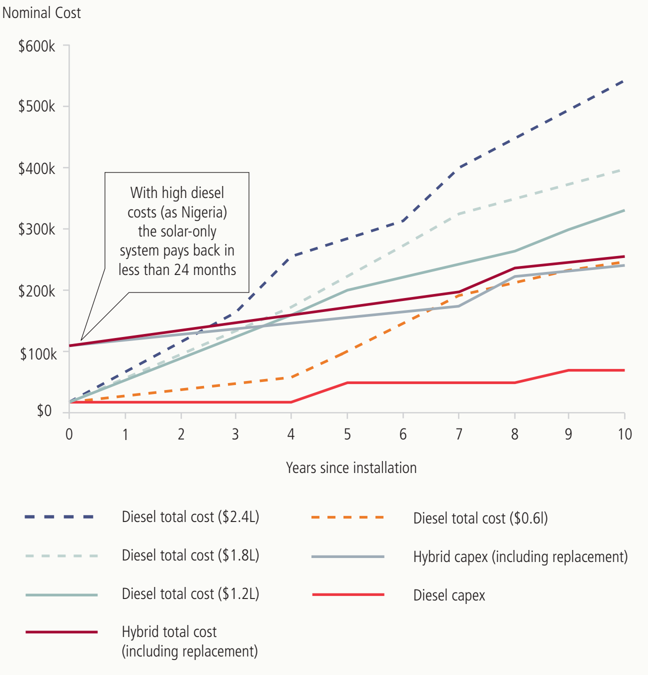
OPEX on a Hypothetical Hybrid Solution Base Station Site in Somalia

BTS Site Load		1,000W		2,000W		3,000W	
Location – Somalia		**Diesel**	**Hybrid**	**Diesel**	**Hybrid**	**Diesel**	**Hybrid**
Capital Expenditure		**US$'000s**					
	Fuel (at US$1.2/L delivered cost)	23.1	0.18	23.1	0.18	27	0.18
	Panel/Generator/Turbine Maint. & Replacement	8.4	4.53	8.4	3.76	8.4	4.89
	Battery Maintenance & Replacement	0.0	2.9	0.0	4.78	0.0	6.63
	Total	**31.5**	**7.61**	**31.5**	**8.72**	**35.4**	**11.7**

Source: Somalia Green Power Evaluation Tool (GPET) site analysis

Tree

Pay Back Period for a Hypothetical Hybrid Solution Base Station Site in Somalia



Source: Somalia Green Power Evaluation Tool (GPET) site analysis

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What tools can I use to check financial & technical viability?

Key Points:

1. HOMER is suitable for specifying green power solutions at specific sites.

Suggested Tools

HOMER is a comprehensive tool for designing small scale green power solutions. The tool was developed by the US National Renewable Energy Laboratory (NREL) and is widely considered the most suitable tool for specifying green power solutions for base station sites.

HOMER

What is HOMER?

HOMER is a tool that is recommended to conduct site specific technical and financial viability of green power solutions in comparison to diesel or grid options. HOMER, the micropower optimisation model, simplifies the task of evaluating designs of both off-grid and grid-connected power systems.

When you design a power system, you must make many decisions about the configuration of the system:

- What components does it make sense to include in the system design?
- How many and what size of each component should you use?

The large number of technology options and the variation in technology costs and availability of energy resources make these decisions difficult. HOMER's optimisation and sensitivity analysis algorithms make it easier to evaluate the many possible green power solution configurations.

When should HOMER be used?

HOMER is an advanced and comprehensive tool, and is commonly used in a number of industries including telecoms for green power solution design for base station sites. Due to the level of complexity it is not recommended to be used without a solid understanding/experience of the process of specifying green power solutions for base station sites. Operators who are new to using green power solutions should seek guidance to specifying sites from green power vendors (see further information on green power vendors).

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How do I use HOMER?

To use HOMER, you provide the model with inputs, which describe technology options, component costs, and resource availability. HOMER uses these inputs to simulate different system configurations, or combinations of components, and generates results that you can view as a list of feasible configurations sorted by net present cost.

HOMER also displays simulation results in a wide variety of tables and graphs that help you compare configurations and evaluate them on their economic and technical merits. You can export the tables and graphs for use in reports and presentations. Where do I get further information regarding HOMER? HOMER is available for free at:
https://analysis.nrel.gov/homer/default.asp

Where do I get data regarding solar & wind resource availability?

Key Points:

1. Assessing renewable energy resource is a critical step in site planning.
2. Wind resource is highly variable and localised.
3. There are numerous sources of public domain and fee based data services.

Renewable Resource Impact

For a green power solution to be successful it requires a suitable solar or wind resource at the location. The size of the required solution depends on the load requirements of the site and the amount of solar or wind resource available. The size of the required solution directly affects CAPEX and therefore the payback period.

Differences between Solar and Wind Resource

There are significant differences between the solar and wind resource.

The solar resource is evenly spread over the local geography, for example, ignoring effects of shade. There is little effect from topography, such as hills & man made structures, on the strength of incident sunlight.

This is in contrast to the wind resource, which is greatly affected by local topography and even local vegetation and land use, for example forests greatly reduce down-wind wind speed.

SWERA	Local specific maps	3 tier	Local met office	Local assessment
- NASA & NREL data - Low resolution - Global - No cost	- SWERA, NREL, JRC data - Improved resolution (various) - Country & regional maps - No cost	- 3tier data - Resolution 5km wind, 10km solar - Global (staggered rollout till 2010) - Fee paying	- Local met office data - High resolution - Availability - various - Cost-various	-Locally collected data - Very high resolution - Availability dependent on time & cost - Cost-various

SWERA (Solar and Wind Energy Resource Assessment)
The SWERA Programme provides easy access to high quality renewable energy resource information and data to users all around the world. The SWERA Interactive Mapping System (IMS) is an online Geographic Information System tool for viewing renewable resource data. Through this interactive system, users can view several renewable resource datasets sets available through SWERA. SWERA provides a global view of renewable resource.

SWERA IMS uses datasets from a number of sources including the US National Renewable Energy Laboratory (NREL) and NASA. The NREL datasets are typically of a higher resolution and accuracy but are only available for specific countries. The NASA dataset that SWERA IMS uses is at a resolution of one degree latitude & longitude and is based on satellite observations. For the wind dataset there is no consideration of local topography or surface affects. Due to this reason and points detailed in section 'Differences between Solar and Wind Resource' data confidence is higher for the solar NASA data than for wind.

SWERA Interactive Mapping System

SWERA also has high resolution maps for specific countries; see the section below on 'Local Specific Maps'.

Local Specific Maps

Following a high level view of resource availability it is recommended to assess whether there are any higher resolution maps available for your specific region. These maps should be used to confirm the data from SWERA and obtain greater accuracy due to improved resolution.

The following table provides a consolidated view of the known maps. If you are aware of other renewable resource maps available in the public domain please submit these via the Contact/Feedback form.

Solar		Wind	
Region	**Organisation**	**Region**	**Organisation**
Africa (Whole)	EC Joint Research Centre (JRC)	Afghanistan Armenia Bangladesh Central America Chile (specific areas) China (specific areas) Cuba Dominican Republic El Salvador Ghana Guatemala Honduras Indonesia (specific areas) Mexico (specific areas) Mongolia Nicaragua Pakistan Philippines Russia (specific areas) Sri Lanka and the Maldives	NREL
Europe (Whole)		Cambodia Laos Thailand Vietnam	ASTAE
Various		China Cuba Ghana Sri Lanka	SWREA High Resolution SWREA High Resolution SWREA High Resolution SWREA High Resolution

3TIER

3TIER offer a fee-paying online renewable energy resource mapping tool built into a Google maps interface. The tool provides both wind and solar data and they offer a variety of services as explained below. 3TIER are a new service and are rolling out the data availability by regions up to 2010.

See further information on the 3TIER solar data source and resolution. See further information on the 3TIER wind data source and resolution.

3TIER Full View Service provides highly customised, high-resolution information about specific wind resources at any global location, scalable from project sites to entire countries. This level of detailed report is more applicable to on-grid, large scale wind farms and would be prohibitively expensive and excessively detailed for use in assessing individual base station site locations.

Local Meteorological Office

To further validate the data provided by the tools above it is recommended to contact both the national meteorological office to see if they have any further local data. Universities and research institutions could also be contacted with this purpose.

Site Specific Assessment

Due to the local variability of wind and the sensitivity of wind turbines to variance in wind speed it may be appropriate to conduct a local site assessment. Usually this will be based on a local installer's experience in the area, rather than a long-term weather monitoring survey. It is rare for long-term weather surveys to be economically viable for single base station sites. Instead collaboration with installers, universities or other third parties are recommended.

What are the CAPEX & OPEX to install a diesel generator on the site?

Key Points:

1. Diesel CAPEX is typically lower than for green power solutions.
2. Diesel costs are rising rapidly due to increases in oil price.
3. Delivery of diesel to remote and inaccessible site locations can be a major contributor to OPEX.
4. Maintenance and replacement costs for diesel generators are significant.

Diesel Generator CAPEX

Diesel generators typically have low CAPEX in comparison to green power solutions even though two are usually installed at each site (for redundancy). Larger generators require industrial transportation and equipment to mount on the site. This significantly increases CAPEX if road access is poor.

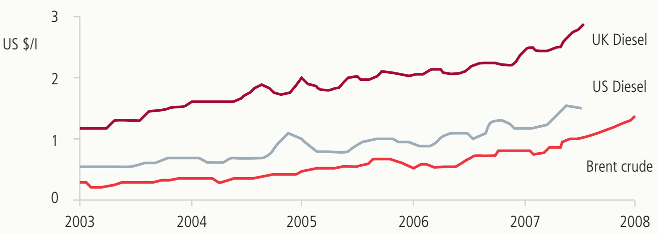
Diesel Generator OPEX

Diesel generators typically have substantially higher OPEX than green power solutions. Generator OPEX has three key elements: diesel price, diesel delivery price and maintenance/ replacement costs.

Diesel Price

The undelivered diesel price is correlated to crude oil price. Crude oil and therefore diesel prices have risen significantly in the past two years. This trend is replicated globally with the exception of a few countries that heavily subsidise diesel, typically oil producing nations.

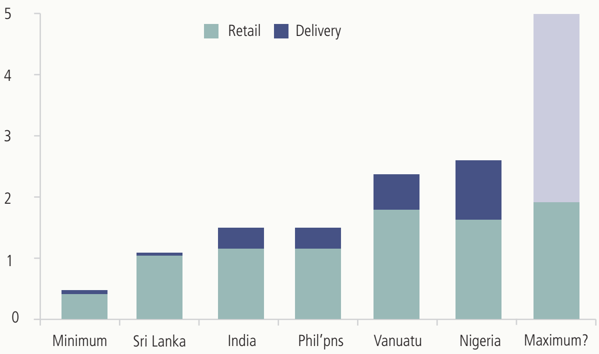
Historical Retail Diesel Prices in the UK & US



Source: EIA

Diesel Delivery Price

Fuel transportation costs can form a significant component of generator OPEX. Isolated off-grid sites with long transport distances will have particularly high delivery prices. Lack of road access to sites and difficult terrain, such as mountains or islands will increase delivery price. Some regions will have delivery issues at certain times of the year due to seasonal weather causing access issues.



Source: Operator interviews

Maintenance & Replacement Costs

Generators have significant maintenance requirements (see further information on diesel maintenance requirements). They also have short life spans of between 3-5 years, which raises replacement costs. Similarly to delivery cost, the cost associated with maintaining a generator will depend on the accessibility of the site. Remote islands, mountains, etc. will have substantially higher maintenance costs.

In some locations there may be significant other barriers to generator use. For example, dust or volcanic ash in the atmosphere can significantly reduce generator lifetime.

What are the CAPEX & OPEX for a grid connection to the site? (Relevant only if grid available)

Key Points:

1. The cost of a grid connection can be significant and varies considerably between countries.
2. Distance from the base station site to the grid and local terrain affects connection cost.

Grid Connection CAPEX

Connection costs to the grid varies considerably by country. They are also impacted by the distance from the base station to the grid and the local terrain. In some countries obtaining a grid connection can be a challenge, see further information on this issue.

Example Grid Connection Costs

Region	Grid Connection
Nigeria	c. US$ 25k
Bangladesh	c. US$ 1.5k
Sri Lanka	US$ 0.4 - US$ 35k
Indonesia	US$ 0.5k-$30k
Philippines	"Cost of extending grid is too high when over 1km away"

Source: Operator interviews

Grid Connection OPEX

Using grid electricity to power base station sites is typically the lowest OPEX solution. The price of electricity fluctuates significantly between regions. A number of operators reported that grid electricity prices are increasing. In some regions where the grid is strained by lack of capacity, prices are rising rapidly (see further information on unreliable grids).

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How do I select a green power solution provider? Key Points:

1. The green power value chain in mobile telecoms is complex.
2. There are various types of players within the value chain.

Solution Provider Requirements

The value chain for green power solutions within the telecoms industry is complex with a number of different types of players. In order to be successful, green power solution providers must do more than simply supply the equipment. They should also offer essential planning and support services including network and site optimisation, supply of green power specific controllers, solution dimensioning and weather assessments.

Green Power in the Telecoms Value Chain

The various players in green power in the telecoms value chain are identified below, together with a brief description of their business focus:

Clean Tech Equipment Vendor	Power Solutions Provider	Systems Integrator	Telecoms Equipment Vendor	Installer	Operator
Manufacturer of green power equipment, serving a variety of industries	Manufacturer and installer of power solutions, including green power	Niche players who design & manufacture solutions tailored for mobile networks	The "Big 5" manufacturers and providers of mobile telecoms infastructure	Local companies that traditionally install generators and carry out civil works	Operators that produce green power solutions from various suppliers, self assemble and deploy

Operator Considerations When Selecting a Vendor

- What is my overall green power strategy (e.g. size of roll-out, locations and topographies)?
- What green power solutions can my current Equipment Vendor(s) supply?
- What local green power expertise and support can my current Equipment Vendor provide?
- Do I want to develop internal green power expertise or is outsourcing more appropriate?
- What Systems Integrators have a presence in my region and should be explored?
- Do I want to maintain the green power equipment or outsource this activity?

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Can you protect against theft & vandalism?

Key Points:

1. Theft of solar equipment is an issue in numerous regions.
2. Theft of wind equipment is rare.
3. There are numerous technical and community based approaches to theft prevention with varying degrees of success.

Green Power Equipment Theft and Vandalism

Theft and vandalism are key concerns of operators and are issues in numerous regions. The issues are far more widespread for solar than wind solutions.

Solar

Theft and vandalism is a major issue for solar solutions. There is a strong second hand market for solar panels in numerous regions and there are also examples of their use in non-generating purposes, such as roofing and coffee tables.

Wind

Theft and vandalism are far less of an issue for wind than they are for solar. This is due to the height, weight and risk of electrocution when removing the equipment, as well as a smaller second hand market in most regions.

Prevention Measures

There are numerous prevention measures of varying success, which include both technical and community ownership approaches. The most successful measures seem to have at least an element of community ownership.

Technical Prevention Measures: Fencing, Lighting, Cameras & Alarms

There are numerous standard security measures to protect a site including electric fences, security lighting, camera monitoring and alarms. There are issues to these approaches. First, many sites are in remote regions where there is no-one to observe or react to standard security measures. Second, electrical methods raise power consumption of the site, which increases the size of the green power solution and raises CAPEX. Finally, the security systems themselves increase CAPEX of the site.

Preventing Access to Panels

An option is to raise panels a few metres from the floor so they cannot be reached. Unfortunately this is only possible with small systems as mounting large numbers of panels on raised platforms is difficult and expensive. Some vendors use special screws that can only be unscrewed with tools that have limited availability. Both approaches have been reported with mixed success.

Resale Prevention

Other theft prevention measures are focused on preventing the resale of panels through a number of techniques. Operators report using marking measures including putting company names on the back of panels using specific colour schemes, and using miniature serial numbers ('micro-dots') on the equipment. Again these approaches have been reported with mixed success.

Guarding

Another common solution is to post guards at the site. The issues with this approach are both cost and the susceptibility to corruption. In regions where guards are posted to protect telecoms equipment, this will be a default option.

Community Prevention Measures

Community based approaches all have an element of local involvement in the prevention of theft. Educating local people to understand the implications of panel theft on the mobile network they use reduces the risk of theft.

Some operators assign a local 'minder' who is responsible for preventing theft from the site. There are financial rewards and penalties for the individual and/or the community dependant on the prevention of theft.

A different approach is to have a small shop at the site, for example a shop selling pre-pay phone cards. The shopkeeper who lives and works at the shop protects against theft as it directly affects his income.

Although not widespread these approaches have been reported to have some success in the prevention of theft and vandalism.

Can the green power equipment be maintained?

Key Points:

1. High quality green power equipment can operate without substantial maintenance for upwards of 10 years - batteries, inverters and connections require more maintenance than green power equipment.
2. The skills required to maintain green power equipment are available globally.

Green Power Equipment

Solar and wind solutions typically have far lower maintenance requirements than diesel generators (see further information on generator maintenance).

Solar

Solar panels do not contain moving parts and as such have minimal maintenance requirements. A typical maintenance programme would involve cleaning the panels and checking electrical connections to batteries and control equipment, every 3 to 4 months.

Inclining the solar panels allows rain to wash any dirt/sand off the panels. The incline of solar panels should be set to your latitude (e.g. 25 degrees North, include the panels at 25 degrees to get the highest output). However, you need at least a 15 degree inclination for the rain to clean the panels. Major manufacturers of solar modules warranty their products for 20 to 25 years (for 80% of rated output).

Wind

The highest quality wind turbines are designed to work without major maintenance for 25 years. As a precautionary measure, many operators recommend annual inspections for damage. For some turbines this visit may coincide with minor maintenance such as replacing 'leading-edge' tape, etc.

Turbines outside of the top-tier often require scheduled replacement of consumable parts including bearings, springs, etc. every 3-5 years. After 5-10 years there may be a requirement to replace major parts such as the fan or tail due to damage.

Approaches to Maintenance

Unskilled local workers can be used for simple routine maintenance such as checking the wind turbine for damage or cleaning solar panels. For more substantial maintenance tasks, trained and experienced technicians must be used to prevent damage to the machine. Our interviews showed there is good access to these skills throughout the developing world.

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What are the availability and price trends for green power technology?

Key Points:

1. Wind turbine manufacturers are expanding production capacity close to developing world demand centres, and lead times are not currently an issue. Prices are expected to stay stable.
2. Solar modules are a commoditised product and prices are expected to fall in the next couple of years.

Wind

There are currently only a handful of top-tier small wind turbine producers and unlike solar panels the products have different design characteristics from large-scale centralised electricity production, and therefore are less commoditised. Current aggregated production is in the 1000's range per year.

Most small wind turbine manufacturers are expecting rapid growth in the next few years and are ramping up production planning capacity to meet demand. Most manufacturers are planning new production sites near developing world demand centres. Lead times are currently not a major issue for wind turbines suitable for base station sites. Inaccessible locations and trade restrictions aside, lead time is typically under four weeks.

The capacity of small wind manufacturers should scale with increased demand and therefore lead times should not be affected in the short term. However, due to the current scale of the industry, any demand shocks created by increased subsidies for micro-generation in developed countries could change this dynamic. Demand increasing more rapidly than supply is the biggest risk to price and supply.

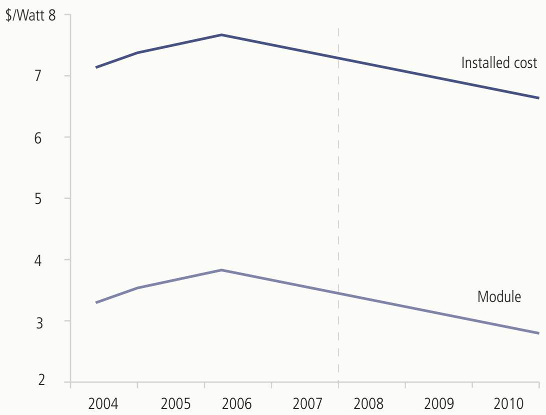
The components in a wind-turbine are mature technologies, with only-incremental improvements expected. Improvements are likely to be in increased reliability from materials and implementation improvements.

Solar

Solar panels are a commoditised product and are widely available in most regions.

There has been a recent (2006) supply constraint on solar panels due to lack of high-grade refined silicon. This silicon supply shortage is largely regarded as having been overcome. Recently and in the next couple of years the top-tier solar companies are installing significant production capacity and are vertically integrating upwards in the supply chain to secure silicon supply mines. Therefore most manufacturers are expecting the price of solar panels to fall in 2009 and 2010, which it did by ~30% or more in many cases. Although rises in other commodities and energy, which input into solar panel production, may offset expected price falls, for example oil, glass, aluminium and steel.

Global Average Price Trends



Source: BizEsp

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Is site sharing with other operators an option?

Key Points:

1. Site sharing can improve the economic viability of network infrastructure investment for low volume rural sites.
2. Providers in India have leveraged site sharing to meet government requirements for rural coverage.

When to Site Share

Site sharing is defined as the sharing of physical infrastructure by multiple operators. Individual operators retain core BTS equipment ownership and network propriety; however telecommunications towers are shared among multiple operators and support the mounting of multiple BTS equipment instances. Core services such as site security are also shared between operators.

Site sharing can be counterintuitive to an operator seeking competitive advantage (i.e. exclusive coverage). Shared infrastructure can be particularly attractive in two scenarios:
1. Urban regions that have been penetrated by multiple carriers.
2. Rural regions with insufficient subscriber volume for cost recovery of independent infrastructure.

Certain governments have instituted regulatory pressure on operators to expand coverage into rural regions with low call volume. One such scenario is the "Universal Service Obligation", an initiative by the Indian government to bring mobile coverage to every village (of targeted villages,90% are completely off-grid). Three Indian operators are supporting this initiative, and have extensively leveraged shared infrastructure (in addition to government subsidy) to achieve goals most efficiently.

Advantages of Site Sharing

- Mobile towers are a shared cost supporting multiple BTS units, reducing deployment costs.
- Site security can be centralised (1 guard).
- Power sourcing (primarily diesel) and backup can be consolidated to provide economies of scale and improved stability (substantiated by service level agreements, typically in excess of 99.99%).
- Operators can be added incrementally to shared sites, which support 2-5 operators.

Disadvantages of Site Sharing

- Power requirements are higher than individual operator sites.
- BTS units are purely incremental power draws.
- Air conditioner and miscellaneous realise some economies of scale, however still require increased power supply.
- Green power is viable as a supplemental power source and can offset some amount of diesel consumption (~ 2-3kW scale), however is not commercially viable for total energy replacement.

Conclusions on Site Sharing

Site sharing provides significant advantages versus individual sites. Outsourced infrastructure permits operators to emphasise core business operations, although consideration for competitive interests must be sustained as well.

The application of green power for shared sites is impacted by significantly increased power requirements of shared sites. Green power is shown to be most cost-effective at lower power levels, and is not expected to be the complete power solution for shared sites. Instead green power acts as a supplemental power source (to reduce the amount of diesel fuel used rather than replace the generator) for shared sites.

Business models and assumptions for shared sites are materially different than individual sites due to the increased load of multiple operators. Many tower and infrastructure companies, such as Bharti Infratel and Indus Towers have now successfully implemented renewable energy power source for shared sites with multiple BTS's. For more details on these implementations please refer to the Bharti Infratel and Indus articles respectively in the November 2010 and June 2011 GPM Bi-annual report.

Use Batteries

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