



Alternative Power for Mobile Telephony Base Stations

Motorola Reach





ALTERNATIVE POWER FOR BASE STATIONS IN MOBILE COMMUNICATIONS

Since the introduction of Mobile Telephony all types of radio communications have seen considerable expansion. GSM, UMTS, and other mobile phone solutions are now connecting 2 billion subscribers with a further billion planned to be added by 2012. Other mobile solutions such as WiFi and shortly WiMax are becoming commonplace, and secure radio systems such as Tetra are in widespread use for emergency and security services. With the spread of wireless voice and data into increasingly remote areas the network operators face a number of challenges.

Such challenges include expensive and complex civil works, long distance equipment transportation, high installation and commissioning costs. In addition, these sites will require electrical power for the base station (BTS) and other associated equipment. Power supply to these sites is often the key issue for service providers building in remote or rural locations.

Motorola has recognized these challenges and is planning to facilitate or provide alternative power solutions for communications operators in all technologies, beginning with cellular operators.

POWER OPTIONS FOR COMMUNICATIONS BASE STATIONS

When planning remote cell sites the service provider has a number of possible power solutions options. Selection of the optimum solution will depend on the local circumstances and could include:

- **Mains power.** This may already be available, or can be provided via grid extension. New grid connections can be very costly and can be also take months or even years to be installed. However where mains is readily available it will normally be the solution of choice. In some cases where there are frequent interruptions to the supply a battery back-up unit can be a wise precaution. In difficult locations, it is not uncommon to have to pay up to \$100k for a mains connection.
- **Generators.** If grid connection is delayed or electricity supply expected to be very intermittent, generators are often installed. These will need to be refuelled, and due to portability and value of both the generators and associated fuel, they may become a target for theft. Bio fuel generators are more environmentally friendly, though may not overcome issues of re-fuelling cost and theft.
- **Solar and Wind power technologies.** Solar and wind power have progressed in recent years and the cost of these has been steadily falling as volumes have increased. The point is being reached now where they can be considered as supplementary or even the primary power source for cell sites in difficult locations. As costs for these continue to fall, and the cost and scarcity of fossil fuels increase, solar and other renewable energies will become increasingly cost effective compared with more conventional power sources.



Industrial and even domestic wind and solar solutions are now widely available at increasingly affordable prices.

AVAILABILITY OF ALTERNATIVE POWER SOLUTIONS

Alternative power solutions are not commonly used in telecommunications systems today, but are being actively evaluated for difficult locations and limited deployments have been made. Industrial and even domestic wind and solar solutions are now widely available at increasingly affordable prices. Incentives are available in some countries which further strengthen the case for using these technologies. Bringing these technologies into Telecommunications applications is expected to bring cost savings and operational advantages to operators and telecommunications service to remote areas.

OPTIONS FOR ALTERNATIVE POWER

- **Solar Power.** The development of high efficiency and affordable solar power has progressed to the point that domestic solutions are feasible in areas of high sunlight. New solar cell technologies are moving the price point steadily down at a time when fossil fuels are increasing in cost. In addition many countries have incentives such as grants to encourage people to buy and use these systems, and when there is excess power this can be sold back to the local power company.

Once installed solar arrays require minimal maintenance, though occasional cleaning will prevent a gradual loss of panel efficiency from dust or bird droppings. Cloud and rainfall may reduce power output for a period, but can have the benefit of cleaning the solar panel surface. Mechanically pointing the array directly at the sun will increase output, particularly at the start and end of the day. Nonetheless, this additional automation increases cost and may add to maintenance levels required. Modelling the local conditions will assist in determining whether a larger static array or a smaller pointing array will be preferable in terms of cost and maintenance.

There is a range of manufacturers of solar power systems, at a number of price points depending upon the environmental conditions within which the array will operate. There is significant scope for the involvement of local contractors to provide supporting frames and tracking equipment.

- **Wind Power.** As with solar power, the availability and maturity of grid, industrial, and domestic wind power generators has accelerated. The available products show a high degree of development, and are reliable, durable and affordable.

A number of trade-offs need to be considered in selecting a wind power turbine for a cell site. The peak wind speeds will determine the size of structure required to mount the turbine, as there is a relationship between the height above ground and wind speed. Options for mounting the turbine include a smaller turbine on a high tower or other structure, while in other cases a lower tower with a larger (and more costly) turbine will be more cost effective.

Clearly the choice of turbine and structure needs to be considered within the context of the complete site as the selection of a tower height is driven by many factors. Strong cylindrical towers are available for mounting turbines and these could also be used for mounting the antennas or even *mini or micro* Base Stations or Remote Heads.

- **Bio Fuels.** The use of bio fuels such as bio diesel is increasing as both the technology to manufacture and use them matures and the cost of fossil fuels continues to rise. Bio diesel is comparatively simple to manufacture and is a very suitable alternative in emerging markets. By growing and using a suitable crop in country the import of fuel is avoided, and employment provided for local manpower.



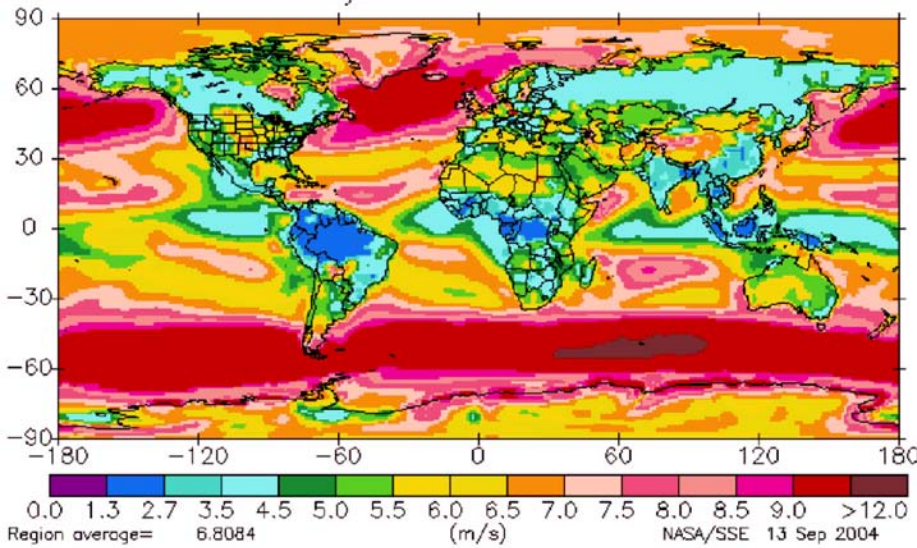
The manufacture of alcohol as a fuel for gasoline engines is an alternative which may be preferred if suitable crops are more plentiful and cheaper than bio diesel. While the use of fuels such as these for remote sites requires visits to refuel the generators, if the sites are easily accessible this may be a more cost effective solution than wind or solar solutions.

- **Fuel cells.** Fuel cells are emerging as a potential power source. They are a cleaner, more efficient alternative to generators for prime power or as an alternative to batteries for backup power. The technology has matured in recent years and has many benefits compared to generators (fuel efficiency, climate resistance, reliable start-up, very compact (e.g. fitting in a 19" rack). A valuable aspect of fuel cells is the silent operation means that potential theft can become less likely as there will be no indication that a power source is operating on the cell site. As they reach volume manufacture in the next few years the prices will fall, they will challenge conventional engine driven generators in applications where other technologies are not cost effective.
- **Pico Hydro.** There are regions of the world with high seasonal rainfalls at times where not only is there low solar radiation but also low average wind speeds. Steep flowing streams or rivers are a source of energy and experimental small hydro power solutions have been tested in some locations with promising results. One significant benefit of

such systems is that much of the civil work can be done by local people, and the turbine and generating systems are not high technology and are easily maintained. In common with other alternative power sources the systems can be sized to provide power to small local communities in addition to the cell site. Other small hydro systems such as submersible propeller turbines can be used in fast flowing rivers.

- **Power Storage.** The nature of power systems which utilize solar, wind or hydro power is that there will be frequent periods where excess power will have to be dumped. In its research on optimizing cell site power solutions Motorola is investigating more efficient methods of managing this process, minimizing the amount of generated power that has to be wasted.
- **Other Considerations.** Security on remote sites is a significant issue, particularly if the power generating equipment can easily be used for other purposes. Diesel generators and fuel can easily be sold if stolen and these will attract criminal activity. Motorola is working with partner companies on a secure BTS enclosure that will house the power supply, fuel, and BTS equipment. Fuelled by Liquid Propane Gas (that may be readily available), the secure site includes a new technology reciprocating engine offering high reliability and low emissions. The use of LPG means that the fuel will be difficult to steal, and also contributes to low emissions.

Annual 50m Wind Speed
July 1983 – June 1993



Reference NASA/SSE web site

GLOBAL WEATHER PATTERNS AND ALTERNATIVE POWER

A detailed analysis of global weather patterns is beyond the scope of this paper, but some general comments are provided.

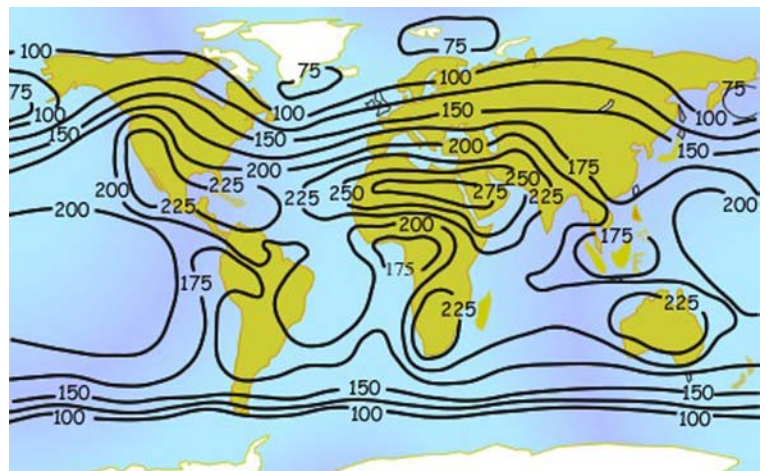
The higher latitudes in Europe, North or South America, and Asia will be challenging for solar power especially during winter months. However, long summer days and windy winter conditions may make a wind/solar combination attractive.

The optimal solution for temperate latitudes will greatly depend on local conditions and generalizations are dangerous. Coastal locations will favor wind, as may flat continental locations or mountainous areas. Solar conditions will vary significantly.

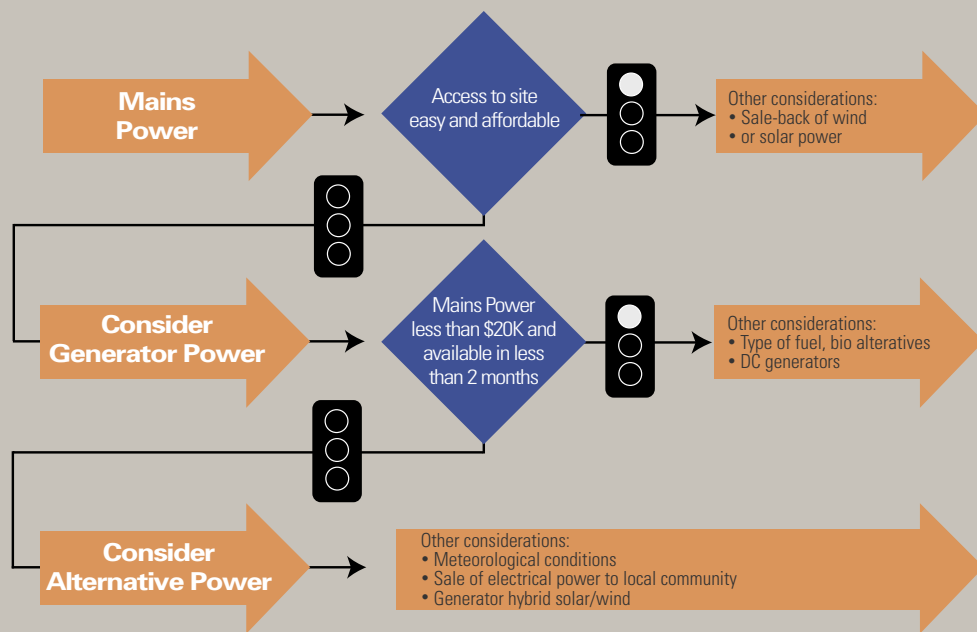
Middle East locations or Western Australia will favor solar solutions and service providers already used these in selected locations. Some of these may also have good wind conditions but the high dust levels may not be conducive for long life for the wind turbines. In equatorial locations there are regions where wind conditions are unfavorable. If good solar conditions exist then these become the favored solutions. However some of these areas have times of heavy rainfall and poor sunlight and if Pico Hydro solutions are possible these could be used in conjunction with solar solutions. Hydro is primarily used for the rainy season and solar for the dry.

The diagrams on this page are taken from Internet sites as examples of the wind and solar conditions in the global and African situations. The global wind diagram illustrates those areas in equatorial areas where wind conditions during this period will be very poor in terms of power potential. These charts give indications of global conditions; the information for specific locations will be required for a meaningful assessment of the viability of wind and/or solar solutions.

This map shows mean solar radiation received at the surface, expressed in W/m². It oscillates between a maximum of 275 W/m², in the cloudless regions of the Sahara and Arabia, up to a minimum of 75 W/m² in the misty isles of the Arctic. The global mean is 170 W/m².



Source http://homepage.mac.com/uriarte/solar_radiation.html



OPTIMIZING BASE STATION POWER CONSUMPTION

The manufacturer of base stations and the overall network needs to ensure that the power requirements are kept to a minimum, thereby reducing the capital and operating costs for power supply. Motorola's Horizon II BTS portfolio for GSM is highly efficient in terms of power consumption and additional measures are being taken to reduce power consumption.

For example by designing out air conditioning whenever possible the power requirements are reduced. All Motorola GSM outdoor enclosures now utilize direct air cooling to take advantage of this power reduction benefit.

Design of the base station to maximize its coverage limits the number of overall cell sites required in the network, and hence the overall power costs for the operator. Motorola offers Base Station features which can be used in combinations to achieve a good balance of capacity, coverage, and power consumption.

The use of high-power micro base stations gives the service operator the ability to mount the base station on a high mast with short RF feeds, and also operate at low power consumption in remote locations.

DEVELOPING THE BUSINESS CASE AND SELECTING POWER SOLUTIONS

Deciding on the best solution will need to be done on a site by site basis. Some sites will be best served by mains power, others by generators, and others by combinations of the renewable energy solutions described above. Motorola has developed a model to fully assess whether a site may be best served by alternative power sources.

Many factors need to be taken into consideration in making a final decision on power supply. In broad terms the process in power selection is as follows:

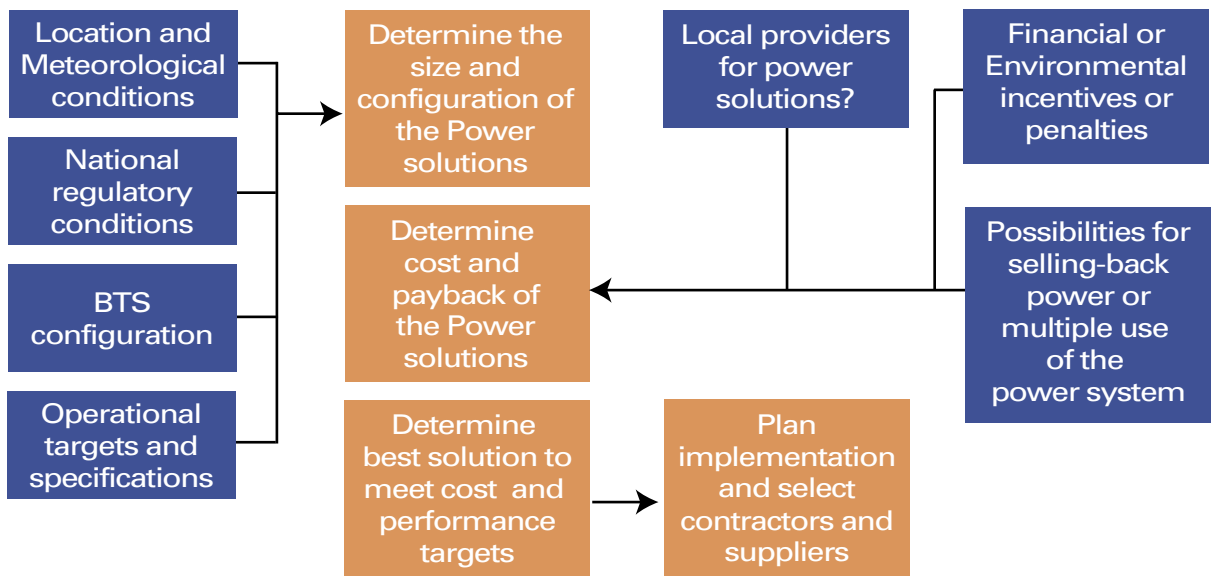
1. Use mains power where it can be quickly and economically supplied.
2. Use a generator if the site is easily accessible.
3. Investigate alternative power if conditions 1 and 2 do not exist.

Initial Screening

Initially a simple model such as the one above can be applied to screen-out those sites where mains or generators will clearly be the favored solutions. This will direct the more detailed modelling to those sites where alternative energy systems are more likely to be cost effective.

The financial triggers in this simple model can be discussed at length but they form a simple means of directing efforts to more appropriate sites.

The additional consideration here will be if the site is a strong candidate for a large wind generator as described above. In this case the sale of electricity back into the grid will change the economic model.



Detailed Technical and Financial Modelling

Operators together with Motorola technical staff can focus on the more problematic sites after the screening process has been applied.

The diagram above shows the model available for specifying, costing, and comparing the alternatives for power supply. It is important that a full set of input information (shown in blue) is assembled to ensure that the evaluation gives meaningful results.

Input conditions to specify the power systems will include (but not be limited to) location, weather patterns, and the power required by the cell site. National or service provider regulations or specifications may also have a significant impact upon the design. For example mandatory environmental requirements may favor one type of technology at the expense of another.

Once sizing is complete the costs of the solutions can be determined. This will entail consideration of local suppliers, incentives or penalties, and sharing cost with other systems such other telecommunication systems or weather stations. In some cases it may be appropriate to size the power system so that excess power can be sold to other users nearby. It may be appropriate to provide power to communities and so grants may be available. Armed with a full set of data the decisions regarding power solutions can be made on an informed basis.

This tool together with advice from local authorities such as weather experts, environmental agencies, and aid partners will provide a thorough analysis of the optimum sites for deployment of systems for evaluation together with the particular issues which will be faced and possible additional funding opportunities.

Motorola already has experience of working with external partners to assist with the deployment of trial systems.

TYPICAL POWER SOLUTIONS

Most of the discussion has related to the current program to address the issues of power for remote GSM base stations. As UMTS spreads into rural locations it will face similar challenges as will WiFi, WiMax, and point-to-point radio links such as the Motorola Canopy family. The table below gives some indication of the power required and the possible solutions for other telecoms solutions. These examples need to be seen as indicators of possible configurations and the local conditions may require larger or smaller solutions.

Application	Site Power Required	Example Solar and Wind solution
GSM Base Station 2/2/2	600-1800W	4KW Solar Array and 6KW turbine depending upon conditions
GSM Base Station 4/4/4	900 – 2300W	6KW Solar Array and 6KW turbine depending upon conditions
UMTS Node B Macro/Fiber 2/2/2	750 – 1000W	3KW Solar Array and 2.5KW turbine depending upon conditions
UMTS Node B Macro/Fiber — 4/4/4	1300 – 1700W	4KW Solar Array and 2.5KW turbine depending upon conditions
Large WiMax Base Station	1.3kW (4 Sector)	4KW Solar Array and 2.5 or 6KW turbine depending upon conditions
Metro WiFi	<30W, includes a backhaul solution	100W Solar Array and small turbine depending upon conditions
P2P link (two heads)	110W for two units	1KW Solar Array and 600W or 2.5KW turbine depending upon conditions

EVALUATION PROGRAM

Following Motorola's successful experimental cell site using solar and wind power combination, a trial will shortly be taking place in Africa. Additional pilot deployments can now be considered. In planning for these a set of planning tools have been developed which can be used to select and dimension the appropriate power sources on a site-by-site basis.

SUMMARY

As the cost of fossil fuels increase and mobile telecommunications systems are deployed in more remote areas without mains power, the value of alternative power solutions will become more apparent. Motorola is providing the research background, planning tools, implementation skills, and purchasing power to assist service providers to implement these solutions where they will be highly cost effective. Motorola looks forward to opening discussions with service providers who wish to consider these solutions.



MOTOROLA

Motorola, Inc. www.motorola.com

The information presented herein is to the best of our knowledge true and accurate. No warranty or guarantee expressed or implied is made regarding the capacity, performance or suitability of any product.

MOTOROLA and the Stylized M Logo are registered in the US Patent & Trademark Office. Canopy is a trademark of Motorola, Inc. All other product or service names are the property of their respective owners.

© Motorola, Inc. 2007
0107networksgms