The Solar Imperative

WHITE PAPER

Using sustainable energy for mass deployment of GSM installations in rural India

Anders Hansson, February 2008

A discussion about low power consumption and how this permits the sole use of renewable energy for GSM site solutions.

1. INTRODUCTION AND EXECUTIVE SUMMARY

Sustainable energy is just about to become an essential part in everyday life for millions of people all over the world and it is fair to say that the associated technology is rapidly maturing and no longer in its infancy.

However, it is one of the most striking paradoxes in the wireless telecommunications industry that the only truly mass produced RBS solutions rely exclusively on existing AC utility grid power and its associated fixed wiring infrastructure.

VNL intends to offer a way out of this dilemma that is in effect preventing millions of people from staying in touch and contributing to the growth and prosperity of their nations [ref 4].

This white paper outlines the practical design criteria for completely self-sufficient GSM base stations that are fed strictly by sustainable energy sources on location in India.

It is demonstrated that with a maximum power consumption that is limited to 150W, safe operation by means of solar power only is not merely a theoretical possibility, but a technical reality.

2. THE SUN AS A POWER SOURCE

For the purpose of this paper, we are only considering the solar energy that can be collected by a flat surface without tracking or the use of mirrors.

At high latitudes, there is a lot to be gained by tilting the receptor and also actively track the sun to collect as much energy as possible, whereas at low latitudes (tropical regions) a flat surface parallel to the ground can receive a very significant amount of solar energy during all seasons.

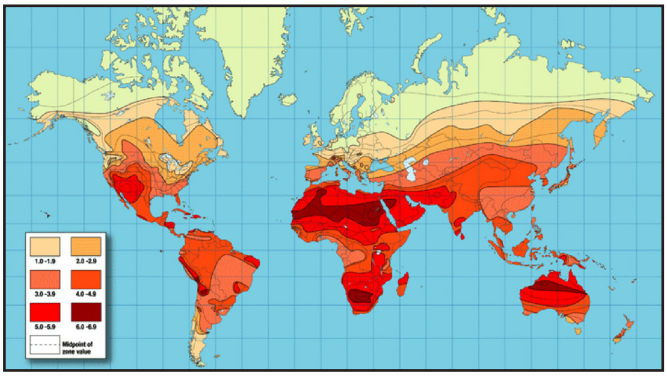

Figure1. World insolation map.

Figure 1 shows a world map with average annual solar irradiation levels. The differences in irradiation are due to a combination of climatic and purely geometric effects. The map legend gives dark red as 6.0-6.9 kWh per square meters per day, where the absolute theoretical maximum value is approaching $24/\pi$. This expression can be found by integrating the power per day that will reach the ground at a location where the sun rises at 6am, reaches zenith at local noon and sets at 6pm without any clouds interfering at any time.

Practically, the above number (7.63) is a very helpful sanity check for site analysis and when converting and comparing data from several sources. It is possible to exceed this value, but only by means of actively tracking the sun.

3. INDIAN SOLAR IRRADIATION DATA AND SEASONAL DEPENDENCIES

Four geographic locations in India have been selected for a refined solar irradiation analysis with the purpose of defining a reliable solar energy power system sustaining an average load of 150W.

From figure 1, one may deduce that 5.0kWh/ square meters and day is a good starting point, but seasonal variations must also be taken into account.
To add margin for sites with rather cloudy weather, specific locations and specific seasons must therefore be identified and analyzed in greater detail.

In figure 2, the red trace at the very top, represents the maximum possible solar irradiation at latitude 29N with no cloud cover [ref 3]. The calculation assumes that the solar array is tilted 29 degrees away from zenith, towards the south. There are two very flat maxima in April and September that approximately coincide with the vernal and autumnal equinoxes, where the radiation will hit directly at right angles to the array once per day.

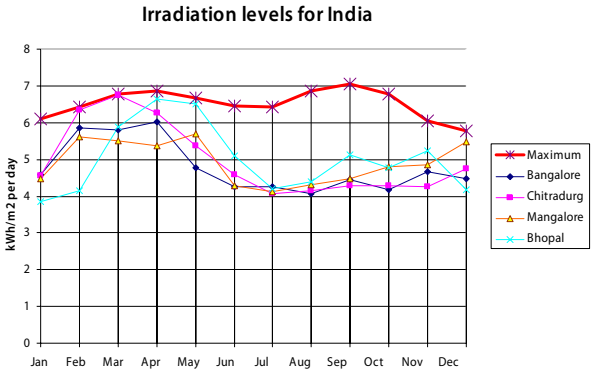

Figure 2. Monthly variation of solar irradiation at 4 locations in India.

The lowest value in the diagram is for Bhopal with only 3.9 in December. All traces converge during July-August, confirming a rather challenging low irradiation average of 4.0-4.2. [ref 1], [ref 2]

4. PHOTOVOLTAIC ARRAY FOR INDIAN GSM SITES

By means of accurately determining the minimum monthly averages of solar irradiation for a number of locations on the Indian subcontinent, it is possible to provide an accurate relation between the average load requirement for the GSM base station equipment and the peak power from the solar power modules.

Basic data:

- *150W continuous load*
- *Minimum solar irradiation 3.9kWh per square meter per day*
- *System losses 15%*

Resulting peak power rating of solar array:

Wp=150*1.15*24/3.9=1062W

Apart from finding the solar array Wp, the expression above also provides the ratio between the system load and the installed photovoltaic peak power.

This ratio will thus be approximately 7.1, since all relationships can be scaled upwards or downwards to predict the impact on solar array area and ultimately cost and weight.

The present VNL design consists of 4x270W polycrystalline solar modules, with the modules covering an area just below 8 square meters.

5. SUPPLEMENTARY WIND POWER

For the Indian subcontinent, average wind speeds are mostly very moderate, bordering on impractically low for the most widely available generators typically found in hybrid solar/wind power systems.

Sites with average wind speeds in excess of 3m/s may possibly be considered with an additional wind generator, but a lower limit of 5m/s would increase the likelihood of achieving more than 1kWh per day. At 10m/s, the entire system load could be handled by wind power alone, but significantly less than 10% of the Indian sites are expected to have such favourable wind resources available.

Most relevant for wind power are locations in Gujarat and Andhra Pradesh where existing weather data shows that a single 400W wind generator like the popular Air-X, by Southwest Windpower, is capable of delivering 2kWh per day for extended periods of time.

This amount is very significant in relation to the daily 3.6kWh needed by the system load, meaning that battery capacity will not be nearly as critical for those locations, while it is still not advisable to trade solar module area for wind power at any of the Indian site locations.

6. CONCLUSIONS

By means of aggressive power saving measures and careful site analysis, VNL is now ready for the mass introduction of GSM installations that are only powered by sustainable energy sources. Solar energy is the primary choice, with wind power providing additional margin at locations where wind is also a significant energy resource.

With the aid of climatic data from 4 different locations in India with only moderately clear skies, it has been demonstrated that 150W of system load can be handled satisfactory by means of an 8 square meter solar module array that does not need a large supporting structure on the ground.

The solution is both economically and technically very attractive and represents a major step forward in the efforts in providing comprehensive GSM infrastructure solutions to emerging markets in general and India in particular.

7. REFERENCES

[ref 1] US Department of Energy, Energy Efficiency and Renewable Energy, EnergyPlus Weather Data

[ref 2] University of California Los Angeles, Energy Design Tool Group, Climate Consultant 3 software utility

[ref 3] European Commission Joint Research Centre, PVGIS PV Estimation utility

[ref 4] "It has been estimated by the London Business School that, in a typical developing country, an increase of 10 mobile phones per 100 people would boost GDP growth by 0.6 percentage points." (Waverman et al., 2005)

ABOUT VNL

VNL makes an end-to-end GSM system that helps mobile operators reach rural markets profitably.

WorldGSM™ is a complete solar powered GSM system entirely optimized for rural markets.

For the first time, operators can build profitable businesses serving low-ARPU users in difficult to reach communities.

The microtelecom revolution is ready to begin and VNL is leading the charge.

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