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FOREWORD

India is today facing an extremely serious and worrisome multi dimensional energy challenge, of which perhaps there is not enough realisation. One aspect of it is rising import dependence on oil products, which may rise to over 90 per cent in the near future, threatening to increasingly compromise our energy security. There is also a great likelihood that this would be accompanied with continuously increasing prices of crude and oil products, which in turn, would lead to rising burdens of subsidies creating problems of fiscal and budget deficit, with its very serious consequences, something we have been witness to over the last couple of years.

It is obvious, therefore, that everything possible must be done to reduce demand for oil products - diesel, kerosene and furnace oil. As far as diesel is concerned, the largest consumer is the transport sector, where unfortunately not enough is being done to curb galloping demand. However, with substantial power shortages, which only threaten to increase, diesel is being increasingly also used for generating power. Five main sectors could be identified – industrial use, large commercial, institutional and residential use; off grid or poor grid areas, geographical areas such as Ladakh or the islands or small towns and many villages; irrigation pumps; and, finally telecom towers.

Fortunately, developments in the renewable energy sector have now found viable alternatives. With the launch of the ambitious National Solar Mission and developments globally, solar pv prices have substantially reduced along with maturing of technology. There has always been talk of when solar pv will achieve grid parity. But we have already achieved diesel parity. And if solar is to replace diesel then there is no financial or economic barrier any more. And there are areas, as shown in this report, where diesel costs are actually much much higher. So would they be in remote areas of Ladakh. Therefore, the time for replacement of diesel by solar has come, and all stakeholders must recognise this so that it can be promoted to the maximum.

The National Solar Mission recognised this need and proposed a reasonably high target of 2000 MW of decentralised applications by 2022. There was an aspirational target of 4000MW. I have no doubt that this is achievable, but it requires conscious attempts so that it is actually achieved. As this report analyses, and others have stated earlier as well, no sector is a better candidate for replacement of diesel by solar than the telecom towers, who are consuming several billion litres of diesel at great cost to the country, to the telecom players themselves and to the environment. The question is how will this happen.

People are generally reluctant to innovate or change. Diesel is convenient and you are used to it. Solar is something new. There is, therefore, the fear of the unknown, including its technology soundness and its economics. The report should debunk these fears. There are enough solar applications now in the country, including in telecom towers themselves, to show that the technology works and the economics is very favourable. There should, therefore, be an explosion.

As Secretary, MNRE, I tried very hard to convince the concerned players to forge ahead and become a leader. But there was general reluctance. One constraint was lack of funds for investment, the other a desire to maximise subsidy from the government, a trait which has become all too common in this country. We were not agreeable to give 30 per cent subsidy to this category as is applicable for other decentralised applications although we sanctioned a pilot project to cover 500 towers at that rate. Some even went ahead and did a few without any subsidy, such was the economics in their perception. We were willing to offer 10 per cent subsidy as a sort of catalyst or go for bidding for 5000 – 10000 towers. We held several meetings but sadly there was no response to either. It was during this period that I had meetings with the telecom regulator to find a way to mandate clean energy use. I am happy that TRAI has come out with regulations. Sometimes, voluntarism does not work for all the talk which industry does regarding green economy or green businesses. And, in this case, there is a strong business case too.

The ball is now very much in the court of the telecom/tower companies. The banking community must come forward for either self installation or to finance RESCOs who will provide the service on payment of rent. The telecom fund could give a subsidy for the new towers which have to be set up as also give a subsidy upto 10 per cent on the solar cost for the old. I would not set very high targets for the next few years but would increase them incrementally thereafter. All new towers in rural areas should, however, be planned without diesel.

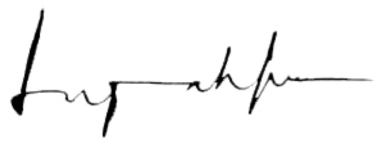
Gradually the urban towers should also be asked to shift, many will have roof space and there can be stilts. If clean energy is demanded, the efforts for having the most energy efficient equipment will also be made and retrofitting will take place in existing towers. Let us not forget that the industry is unnecessary consuming substantial amount of power too, which today has become a scarce commodity. The report describes this need clearly.

There are also opportunities to try biomass. We tried to promote the concept of rural electrification using towers as an anchor load for rural electrification. But that has not worked because of various reasons though pilots are being tried where 2-3 towers co –exist. There are also pilots being done to have dedicated small gasifiers only for the towers and there are indications of success. They need to be studied.

One problem, which is both an incentive and a threat, is the theft of diesel. On the one hand, this is increasing the cost to the operator. On the other, this is leading to resistance to shift from those who are stealing. This problem would have to be addressed, because the problem is greatest where the need is also greatest and perhaps also the influence of such people.

I would like to compliment Greenpeace to have initiated this study and to make efforts to persuade the stakeholders to go forward seriously, urgently and as far as possible on the path of a green telecom industry. I don't mind if I have to pay a paisa per call extra, but the telecom towers companies owe it to this country to use clean energy. From this responsibility they must not run away.

I also hope Greenpeace will follow with other reports, perhaps in a series, to study other areas where diesel, furnace oil and kerosene use can be reduced.



Deepak Gupta
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EXECUTIVE SUMMARY

In the last decade, India's telecommunication industry witnessed a 2600 per cent growth in the subscriber base. Currently it is the second largest of the global telecom markets and is projected to overtake China. Analysts say that despite all challenges India's telecom market will surpass $100 billion-mark by 2015. If the region's, successful telecom companies can grow at a sustained rate, by 2020, the Indian telecom sector will be shaped as an important catalyst in the crucial evolving economic structure of India.

Today, 951 million people are connected to each other wirelessly making telecom the greatest catalyst in India's growth story. This prospect by the year 2020 will make India an information society and a knowledge based economy.

India's dense urban population is partly responsible for this increased growth, while, 60 per cent of rural India is still without telephone connection, wireless or otherwise. With millions still to be connected, telecom sector today is on a verge of a historic transformation. However it is by no mean pre-ordained.

Through its history, the telecommunications sector has often demonstrated its robustness in downturns and periods of market uncertainty. The report shows that the path till 2020 might not be a linear and will be full of crisis and challenges.

Stagnating revenues and decreasing profit margins marred the industry till now. As telecom networks focus on sustaining growth and expansion into these new markets and areas, they are increasingly troubled by the inadequacies of the power grids and risks of unexpected outages, sometimes of extended duration. But such inadequacies have not stopped the companies from an unprecedented proliferation in the number of network towers which grew by almost 8 times in a span of 6 years from some tens of thousands (over 50,000) in 2007. The number of towers, in India at present, stands at a little over 400,000. Nearly 70 per cent of the overall towers are situated in these inadequate areas.

With the mobile subscriber base set to touch 1 billion by 2013-14 and the rollout of 3G services, an estimated 100,000 more towers will be required to support additional capacity.

This has lead to an increased usage of diesel generators, being the easiest mode of alternative electricity generation available in the market. Resulting in a growth that still continues to come at the cost of the climate and the economy at large based on finite resources.

An estimated 3.2 billion litres of diesel was consumed by the telecom industry last year which is forecasted to reach 6 billion litres by 2020. With another 1, 00,000 towers on its way, the telecom industry will not only push up the demand for diesel and further burden the government but also will be responsible for nearly 8.4 million tonnes of carbon dioxide emitted into the atmosphere.

While the current model of diesel-powered networks offers the sector short-term capital gains, such a model of operation is likely to limit growth and profit generation prospects of the sector in the long term.

The growing appetite for energy, the implications of climate change, our continuing damage to the environment, plus the scarcity and increasing prices of fossil fuels, create the appropriate conditions for to develop the sector's use of renewable energy.

It's fairly clear that the Indian telecom industry is in a massive expansion mode for most part of the next decade. If business as usual [BAU], continues as usual it might cripple the telecom sector and will thus have a cascading effect on the economy and rob the potential affluence of billions of Indian by 2020.

It was such a realisation that made the Telecom Regulatory Authority of India [TRAI] come with a directive which assures sustainable growth path for the telecom industry, in particular to its energy consumption and carbon emission perspective.

Telecommunication in India will need to sustain high growth rates, address the issue of energy scarcity for rural penetration, and adapt itself with a road map to a low carbon growth. To meet these challenges, business and political leaders need to devise bold and innovative national policies, while pursuing avenues for cooperation.

Meeting these challenges would also require action of individual companies at the industry level. Collective action by the companies and as a more proactive and constructive role at the global level is the need of the moment.

The renewable energy market space is also extremely competitive and the transformation underway has the potential to greatly influence the significance of renewables in India's power and energy planning and also address the issue of energy security.

Already, India's substantial economic growth is placing enormous demand on its energy resources. The demand and supply imbalance in energy sources is pervasive requiring serious efforts by Government of India, to augment energy supplies. India already imports 80 per cent of its crude oil.

There is a threat of these increasing further, creating serious problems for India's future energy security. Looking at a significant risk of lesser thermal capacity being installed on account of lack of indigenous coal in coming years because of production, logistic and social constraint's along with increased dependence on imported coal.

Going with these the country today faces possibly a severe energy supply constraint. At the same time, a very large proportion of Indians, close to 300 million continue to live with no access to electricity and other forms of commercial energy.

By adopting a business model based on distributed system the telecommunication sector can secure its power requirements for its information-based infrastructure for the 21st century. Going with this, an intellectual investment in green technologies will surely add economic robustness and long-term profitability for telecom Industry. However, telecom companies are yet to integrate low energy and low carbon considerations across their operations and portfolio to any serious level.

The report looks at the development of all plausible scenarios, of where the sector could be in 2020 in terms of clean energy usage.

From the current business as usual scenario based on GOI directive to use renewable energy usage to an adoption of stringent energy efficiency measures to reduce overall demand. This report explores the market created for renewable energy companies through this transition and the investment potential that would accompany this.

It also looks at deducing and recommending changes in policy mechanisms and strategies much needed to avoid a longer gestation period for this transformation to take place. This will include key incentives for the development of renewable energy within the telecom sector. Some of the key findings in terms of implication of the TRAI directive from the report include:

- *Enforcement of the TRAI regulation would save more than 540 million litres of diesel on an average annually, and about 3.5 billion litres of diesel, cumulatively, by 2015.*
- *The cost and energy savings in terms of revenue expenditure from this will be at minimum of INR 2430 crores annually.*
- *About 9 million tons of carbon emission could be saved in just over 3 years' time.*
- *In urban areas this will lead to an additional annual reduction of 123 million litres of diesel and the accumulated revenue savings for the operators, could reach a staggering amount of INR 8,300 crores over the 5 year time period from 2015 to 2020.*

With its immense contribution to India's growth over the last two decades, the telecommunication sector is well placed to transit to a business model that relies on energy efficiency measures, in combination with harnessing clean energy sources for its operations.

Greenpeace is calling on the telecom industry to focus on managing its energy and carbon by substantially shifting its power generation for network operations to renewable sources, and to proactively advocate for economy-wide policies that combat climate change and increase the use of renewable energy.

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PART I

INDIAN TELECOM INDUSTRY & THE DIESEL PROBLEM

INDIAN TELECOM INDUSTRY & THE DIESEL PROBLEM

1.1 INTRODUCTION

India has been growing at an average rate of almost 8 per cent for the last five years and has emerged an economic superpower in the world. The telecommunication sector is at the helm of this growth story. It has been established[1] that the level of a nation's telecom penetration has direct bearing on its gross domestic product (GDP). A study by Dr Christine Zhen-Wei Qiang, lead economist at the World Bank, shows that for developing nations such as India a 10 per cent increase in mobile penetration makes a positive difference of 0.8 per cent to the economic growth. Figure 1 shows the impact of information and communication technology (ICT) industry on the economic growth of a country.

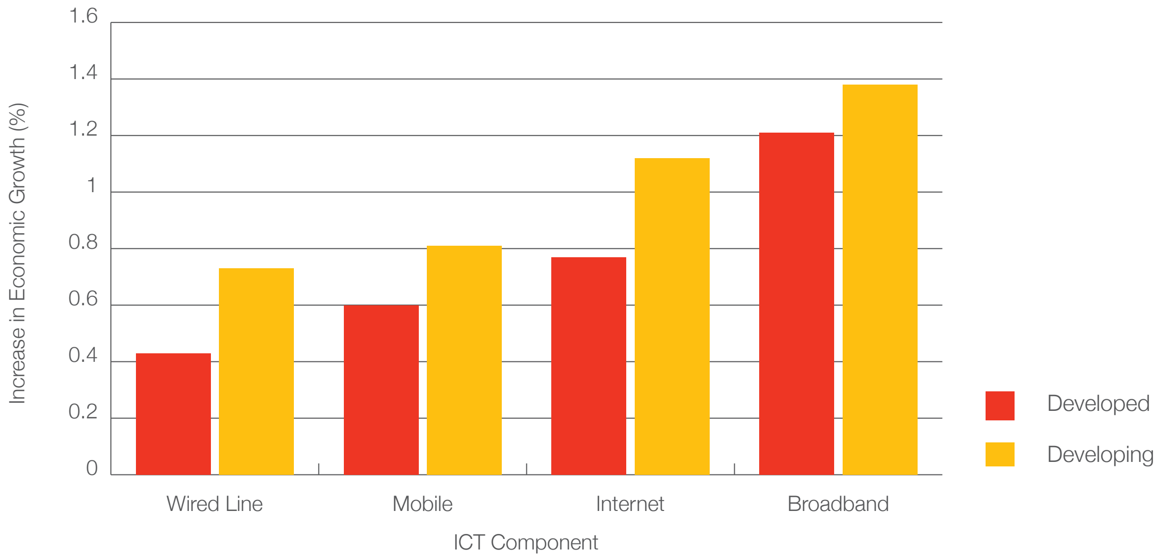
"A 10% increase in mobile penetration makes a positive difference of 0.8% to the economic growth."

In the last decade, India's telecommunication industry witnessed a 2600 per cent growth in the subscriber base, which touched 926.17 million in December, 2011[2]. The wireless base is expected to touch 1 billion in 2013 having multiplied by five times in the last 6 years from 165 million in 2007 to 893 million by the end of 2011 (Refer Fig. 2). It makes the fixed-line subscriber numbers look puny.

India's dense urban population is partly responsible for this increase in the wireless subscriber base. Figure 2, in which the national teledensity [3] growth is broken down into rural and urban components, shows that in 2007 the urban teledensity was at 45 per cent, almost 23 times of the

Figure 1: Impact Of ICT Components On Economic Growth

Sources: Mobile Telephony: A Transformational Tool for Growth and Development



[1]Mobile Telephony: A Transformational Tool for Growth and Development
[2]TRAI Annual and performance indicator reports,2001-2011
[3]Number of telephones per hundred people

corresponding rural figure which was at 2 per cent.

The urban population were savvy to spot the advantages of wireless and mobile communication. As a result the wire line subscriber base witnessed negative growth in the number of additions. It was clear where India's telecommunication industry was headed! The urban subscriber base boomed on a year-on-year basis post 2007, outstripping the sluggish rural expansion. Taking the cue, telecom operators like Airtel, Vodafone, Reliance launched massive expansion plans in the metros and circle "A" cities leading to an unprecedented jump in the number of wireless devices, pushing the urban teledensity past 100 in 2009, a two-fold increase within 2 years.

Meanwhile, rural subscriber growth remained slow. This could be related to low affordability of mobile phones at rural level and low revenue potential of these areas, where minutes of usage (MoU) were less than cities. But Figure 2 shows that rural subscriber base as a percentage of the total has been on an upward trend in the last few years. A glance at the current teledensity in urban areas might give a clue to this trend. According to Figure 3 the urban teledensity is now over 160 per cent, indicating a saturation point in these areas.

Figure 2: Wireless Base[4]

Sources: TRAI

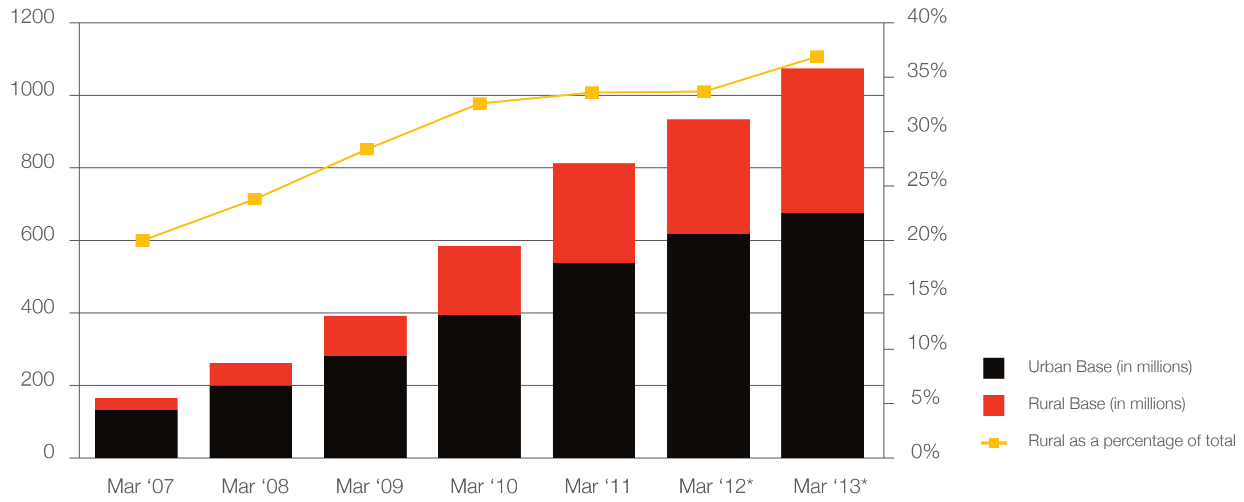
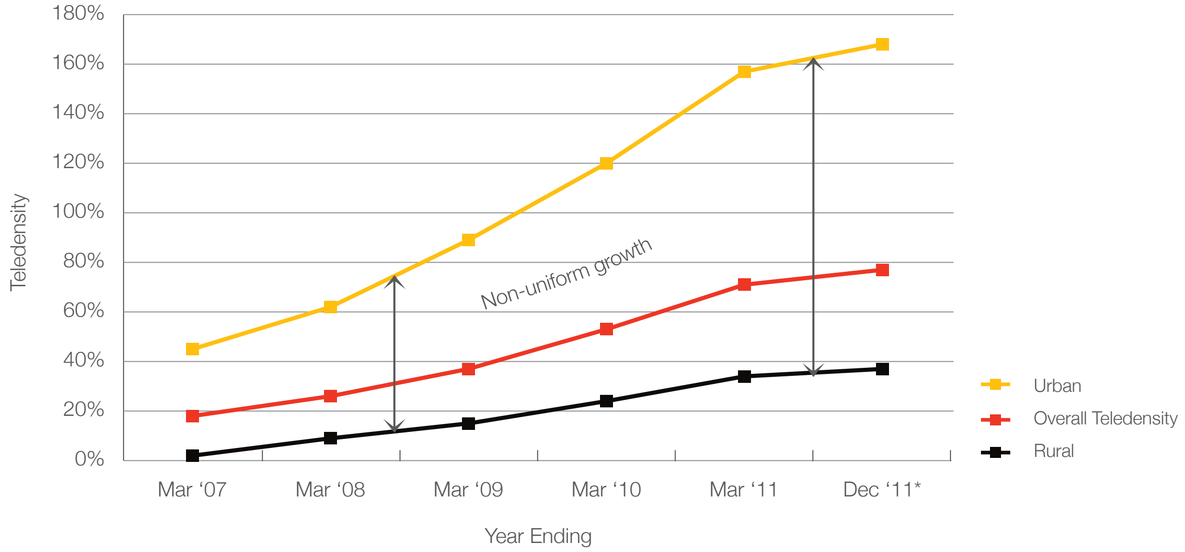


Figure 3: Teledensity Growth[5]

Sources: TRAI, EAI analysis



[4]Sources: TRAI Annual and Performance Indicator Reports, See Annexure for Assumptions

[5]Sources: TRAI Annual and Performance Indicator Reports, EAI analysis

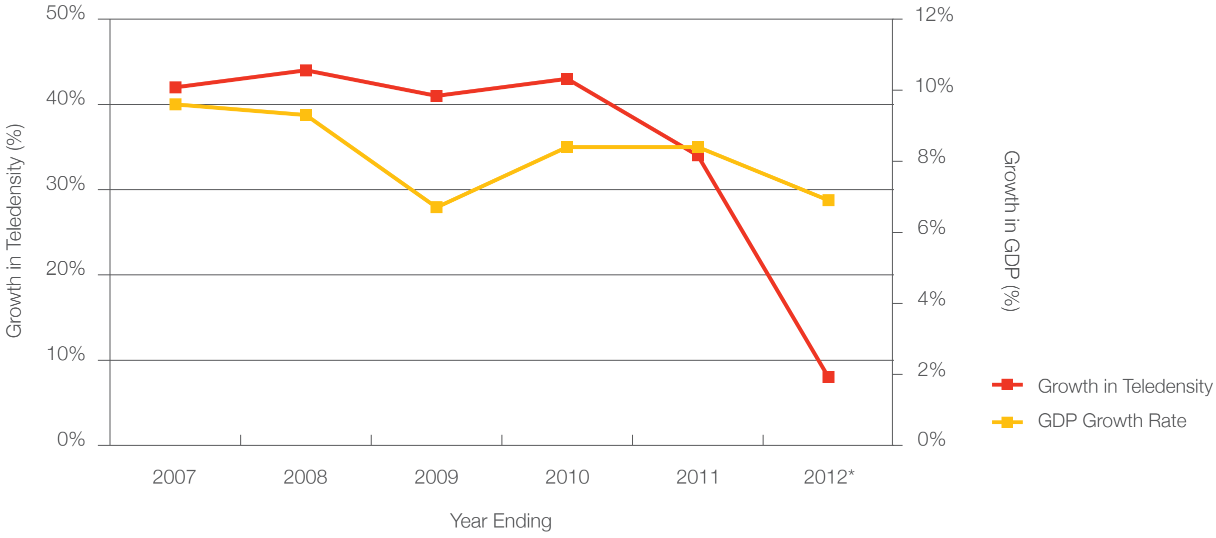
1.1.1 A New phase

The growth of the telecom industry is vital to the sustenance of the extraordinary growth rate of India. The dip in last year's growth rate could be a reflection of the downtrend of the telecom industry. Figure 4 compares the growth rates of India's GDP and teledensity over the last few years. The GDP growth follows the upward or downward trend in the teledensity mostly. Therefore it is imperative for the government to recognise the critical role of telecom in the future growth of the country.

"It is imperative for the government to recognise the critical role of telecom in the future growth of the country."

Meanwhile the telecom industry has realized that the next phase of its growth is dependent on its innovation at the network management and service value levels as it spreads across rural India where consumer spending is lower and the costs of operations are significantly higher. The following chapters will discuss the challenges that they face and the crucial role that the government will play as India progresses toward 1 billion mobile subscribers.

Figure 4: Teledensity Versus Gdp Growth[6]
Sources: TRAI, EAI analysis



1.2 OPERATING COSTS, NETWORK INFRASTRUCTURE & THE ENERGY PROBLEM

1.2.1 Operating Costs

The urban penetration levels saturated in 2009-10 but over 60 per cent of rural India was still without telephone connection, wireless or otherwise. It was clear to telecom operators where their next big market lay. They ventured into rural markets and made significant capital expenditures to expand capacity and coverage in these regions.

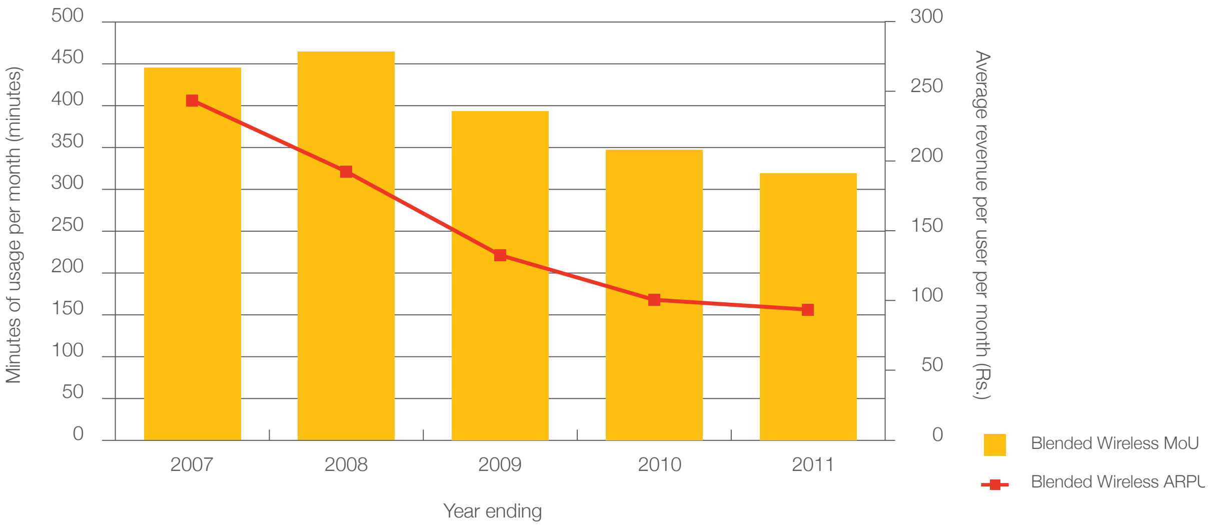
However, stagnating revenues and decreasing profit margins marred the industry even as subscriber additions rose steadily from the rural side. The telecom industry's ARPUs and MOUs (Refer Figure 5) tumbled as the operators discovered that the dynamics of rural mobile telephony were different from those in urban markets.

A look at the network operating expenditures during this period makes the picture clear. While revenue growth remained relatively flat over the period, operating costs increased

[6]Sources: TRAI Annual and Performance Indicator Reports, EAI analysis

rapidly. It put downward pressure on the net margins. Some large players felt less pressure as they achieved significant economies of scale.

Figure 5: Falling Arpus And Minutes Of Usage Over The Last Few Years[7]



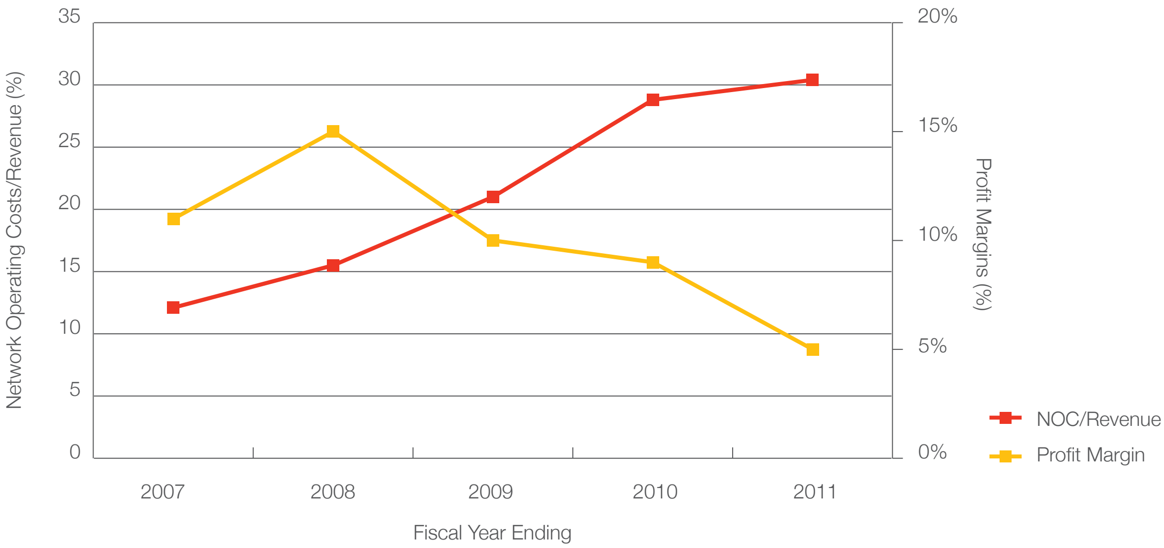
Idea cellular is a good example with more than half of its subscribers in rural areas. Their annual financial result reveals that their network operating costs grew three times faster than their revenues between the years 2007 and 2011. Their operating costs as a percentage of revenue more than doubled in the span of four years from 12 per cent to almost 30 per cent. Figure 6 shows the effect of the spiralling operating costs on their profit margin. Compare this with the industry leader in the same period and it is evident that Bharti Airtel (Figure 6) managed to leverage their position as the big daddy to ensure stability despite burgeoning network operational expenditures.

"Their operating costs as a percentage of revenue more than doubled in the span of four years from 12% to almost 30%."

A closer look at the financial statements shows that the major contributors to network operating costs are rent, power and fuel charges. The strong correlation between increasing energy and operating costs for Idea cellular can be inferred from the figure below.

Figure 6: A Comparison Of Rising Operating Costs Versus Profit Margins between Idea & Bharti Airtel[8]

Sources: EAI Analysis, Press releases, Companies' Financial Statements



[7]Sources: TRAI Annual and Performance Indicator Reports

[8]Sources: EAI Analysis, Press releases, Companies' Financial Statements

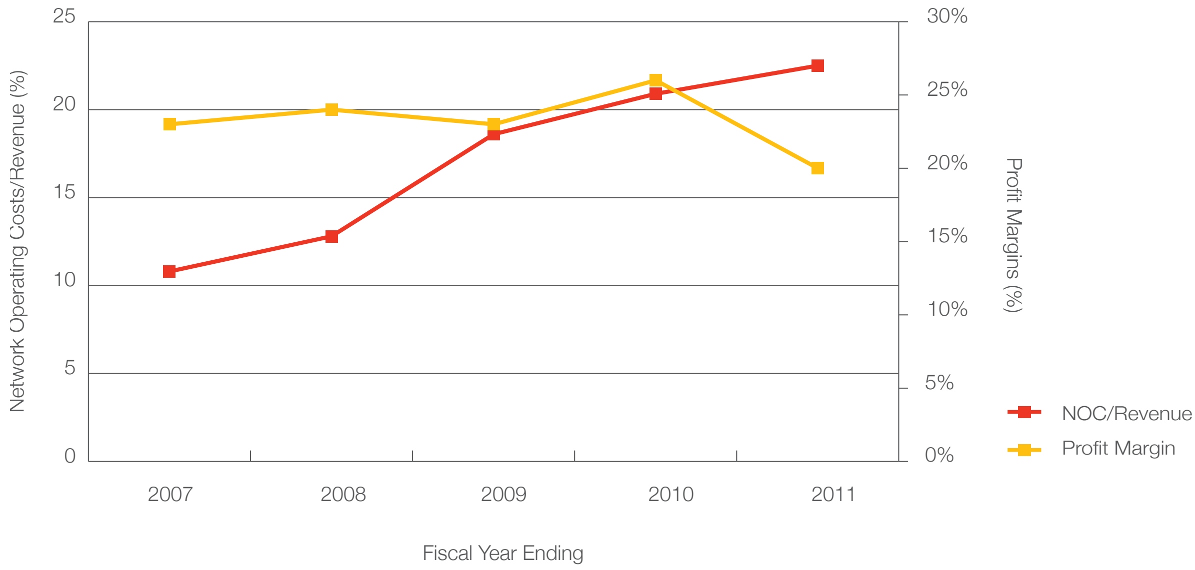
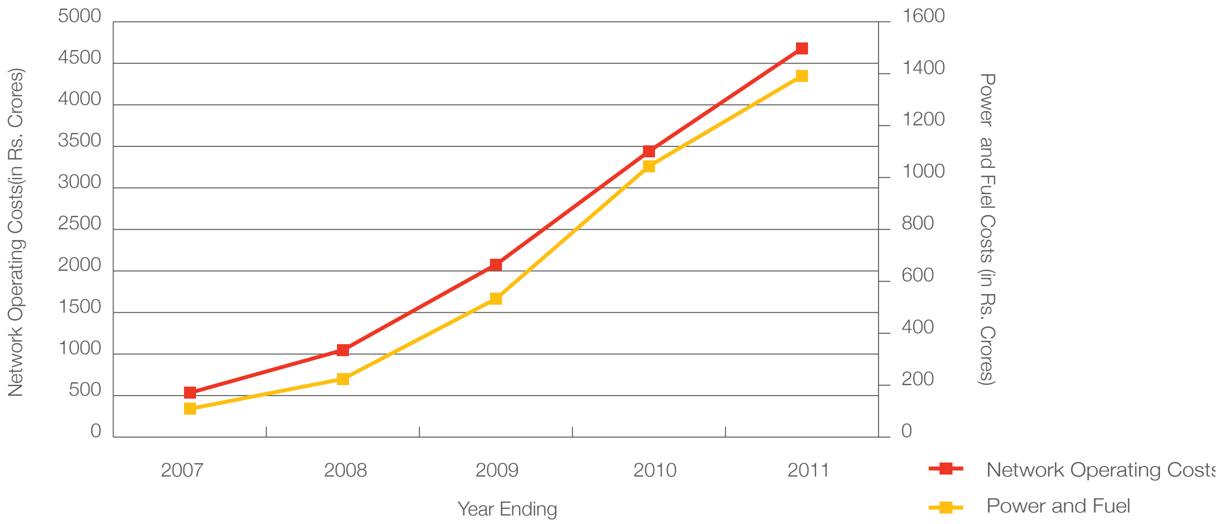


Figure 7: Correlation Between Network Operating Costs & Energy Costs[9]

Sources: EAI Analysis, Press releases, Companies' Financial Statements



Energy is a variable component of the passive infrastructure of a mobile network. Steep rise in energy costs coupled with high cost of constructing towers prompted operators to think about passive infrastructure sharing. This approach brings down the additional cost of expanding networks. We shall go into this in detail in the subsequent sections.

1.2.2 Network Infrastructure

Network infrastructure is at the core of any telecom operator's business. The network facilitates the transmission and receipt of voice and data over radio frequencies when calls are made and text messages are sent.

The cellular phone network consists, primarily, of three components: mobile switching centres (MSC), base station controllers (BSC) and base transceiver stations (BTS). Any region is divided into hexagonal cells with BTSs at their centre. Several BTSs fall under the control of one BSC and a group of BSCs fall under the control of one MSC. The BTS is located at the centre of the hexagonal cells of each region. The switching and handoffs (when a person moves out of the coverage region of one BTS, the signal is handed off to the next BTS) are handled by the base station controller, which has a group of BTSs under its control. A mobile

[9]Sources: EAI Analysis, Press releases, Idea Cellular Financial Statements

switching centre (MSC) handles the switching among various base station controllers (BSCs).

This intricate system requires an expansion of capacity and coverage. To enable communication among the network components, antennae are placed on towers specially constructed for them. An antenna can be used by more than 1 BTS to transmit and receive signals. With this in the background, we now venture into tower operations.

1.2.2.1 Tower Dynamics

Telecom mobile networks can be divided into active and passive components. The active components consist of the electronic equipment used to receive, process and transmit radio waves while passive components support the proper functioning of active components in the form of sheltering, mounting and providing energy for operations.

The rapid growth of the telecom industry automatically created a demand for network infrastructure and tower companies ramped up construction. Its number grew by almost 8 times in a span of 6 years from 50,000 in 2007 to a little over 4,00,000[10] towers at present. With the mobile subscriber base set to touch 1 billion mark by 2013-14 and with the roll out of 3G services, an estimated 1, 00,000 more towers will be required to support additional capacity.

"The rapid growth of the telecom industry automatically created a demand for network infrastructure and tower companies ramped up construction. Its number grew by almost 8 times in a span of 6 years from 50,000 in 2007 to a little over 4, 00,000."

The deployment of towers involves significant capital outlay, and with the expansion in terms of capacity additions the operators have started to look at passive infrastructure sharing models widely prevalent in developed markets. Infrastructure sharing reduces costs of expansion significantly, lowers barriers for entry of new players and brings down the operational expenditure.

The idea of infrastructure sharing is gaining traction in India. A look at the tenancy ratio, which is the average number of BTSs that a tower houses over a time period, is a good indicator of the progress of infrastructure sharing. From 1.22 in 2008, the tenancy ratio has risen to 1.60 in 2010 and is inching towards 1.80, bringing it closer to the optimal figure of 2[11]. The tenancy ratio contributes to the capital efficiency of a telecom system.

1.2.3 An Energy Perspective: Energy Consumption, Tower distribution and the grid problem

The components of a cellular network require a continuous supply of electricity to function. The telecom industry has one of the highest uptime requirements demanding stable electricity supply 99.999999% of the time. Its failure can cause a dramatic fall in the revenues of the sector on a minute-to-minute basis. Hence it would be appropriate to look at the power requirements of different mobile network components. Since BSCs and MSCs are mostly situated in areas where grid availability is ensured and continuous, the focus is primarily on BTS sites.

1.2.3.1 Power Requirements

BTSs are the biggest consumers of electricity in an outdoor tower site. The older generation BTSs were prone to overheating on constant usage and were cooled inside shelters by air conditioners. Air conditioners, especially the older ones, are high consumers of electricity; a

[10] Analyst Reports (FICCI, ICRA), Press releases, EAI Analysis
[11] Analysis Reports(Infrastructure sharing, IIT CoE), EAI Analysis

0.9 ton AC requires over 1 kW of power. This doubled the load of an indoor BTS. The new BTSs have higher operating temperatures and outdoor sites are preferred to save energy costs.

The older generation BTSs also required more power than the ones currently available in the market. A 2 x 2 x 2 configuration BTS require about 1.3 kW of power while the higher capacity versions (4 x 4 x 4 & 6 x 6 x 6) require 2 and 3 kW respectively. When coupled with 1.5 ton air conditioners, they need power between 3-4.7 kW, which means continuous power supply through the day. On the other hand, new generation BTSs require lower amount of electricity and can operate under much higher operating temperatures, eliminating the need for air conditioners. After the influx of these new BTSs into the market a few years ago the number of outdoor installations has gone up considerably, reducing the ratio of indoor to outdoor BTSs to about 60:40. These BTSs cut the energy consumption by half, and even with air conditioners they require power between 2.2-3.4 kW.

Table 1: Power Consumption For Old Generation Btss Of Different Capacities[12]

BTS Configuration	Load (kW)
2 x 2 x 2	1.3
4 x 4 x 4	2
6 x 6 x 6	3

Source: P.K.Panigrahi report, DoT

Considering the above factors, it can be deduced that the tower industry consumed at least **16.5 billion units**[13] of electricity in FY 2011-12. This is approximately 2.5 per cent of **ALL** of India's electricity consumption in the same period and one half of the shortfall the country faced in April 2012. With the number of towers set to reach 5, 00,000 in the next three years, the electricity demand would increase to at least 22 billion units if the same trend continues in sourcing electricity.

1.2.3.1.1 Electricity Sourcing

Reliable and continuous power supply to network equipments is of primary importance to the business-as-usual functioning of the telecom sector. The mode of electricity supply to a tower is directly dependent on its location. Therefore, a good way to look at the electricity supply mix for Indian towers would be to segregate them on the basis of location. This will be covered in the following section.

1.2.3.2 Tower Distribution

The first stage of expansion was mostly in urban areas. Being densely populated the network traffic was high. Lack of space meant that there could be few towers with the onus to handle the hectic traffic. This is a possible explanation for the skewed tower distribution between rural and urban areas.

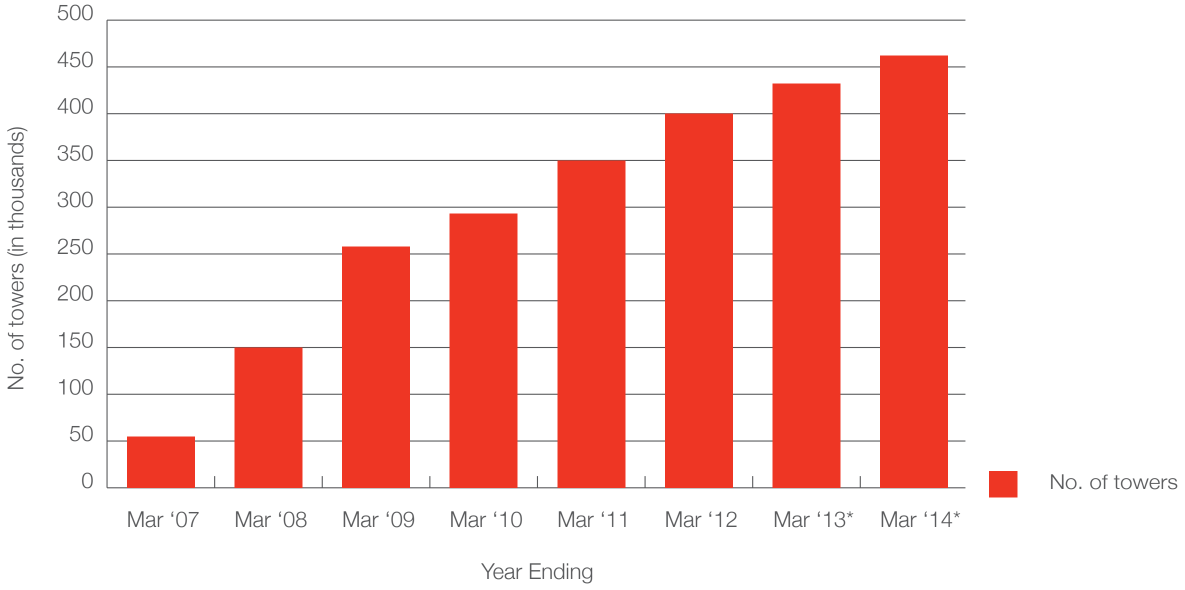
Currently, only around 30 per cent of the telecom towers are situated in urban areas and they are mostly of the rooftop variety.

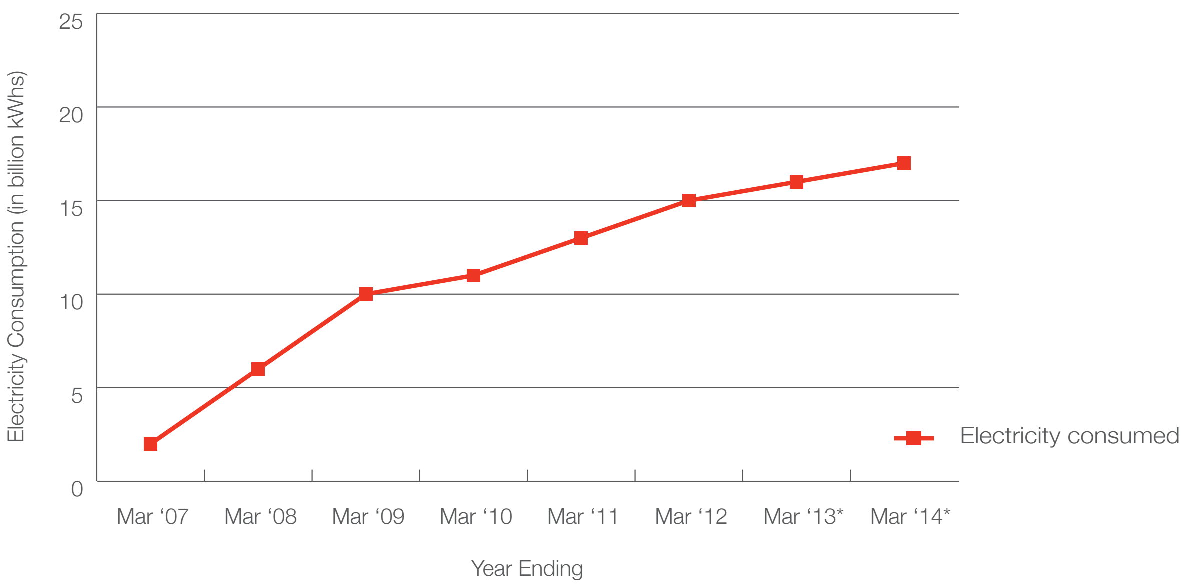
For rural and suburban expansion the dynamics were slightly different due to sparse population. Tier B and C cities, classified as suburban areas, formed a large chunk of the expansion program. The expected traffic turnover here was between that of the rural areas and the urban localities. Operators wanted to ensure maximum coverage of these areas because of its sheer potential. A large number of towers mushroomed in these regions due to cheap and easily available real estate and nascent stage of infrastructure sharing. Now nearly 70 per cent of the overall towers are situated here and the ratio of tower distribution between suburban and rural areas is close to 50:20.

[12]Source: P.K.Panigrahi report, DoT
[13]Assumptions and Analysis in the Annexure to this report

Figure 9: Growth In Towers And Corresponding Electricity Consumption

Sources: EAI Analysis, Press releases, TRAI data





1.2.3.3 Overview of the Indian power sector & the grid problem

Lack of a developed national grid network is a major cause for power-supply snags to the telecom towers. Over 300 million people, i.e., roughly 20 per cent of our population, don't have access to grid electricity. While a majority of these people reside in the north-eastern states like Bihar, UP, Assam, Sikkim; other pockets across the country also remain completely isolated. So even if the country had abundant power supply, these regions would still be out of its loop.

"Over 300 million people, i.e., roughly 20% of our population, don't have access to grid electricity."

In March 2012, India faced an electricity supply deficit of 10.1 per cent. The deficit was due to a sudden spurt of demand brought by the supernormal growth in the last decade. This is exacerbated by a severe shortage in coal, which is largely imported. As a result of this, even some states that are connected to the grid like Tamil Nadu, Kerala, Karnataka, Madhya Pradesh and Punjab face prolonged and unscheduled power cuts. Table 1 shows the growth in power supply deficit from 2011 to 2012. It reveals southern and north-eastern regions of the country face severe power crisis.

Table 2: Electricity Shortage In Different Parts Of The Country[14]

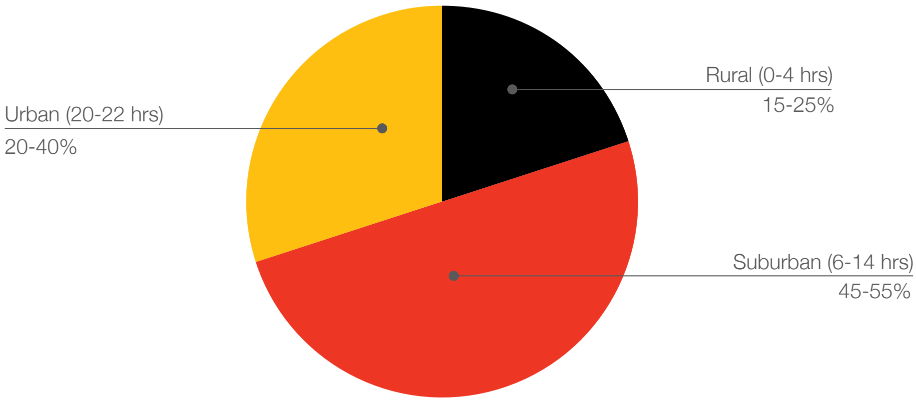
Electricity Supply Deficit (%)		
Region	March – 2011	March-2012
Northern	-5.6	-5.8
Western	-12.2	-9.1
Southern	-6.0	-16.7
Eastern	-4.0	-4.3
North-Eastern	-7.7	-10.1
All India	-7.7	-10.1

Source: CEA

Since telecom relies on 24 x 7 supply of electricity, the operators had to tackle this void to expand into these areas. They turned to the easiest mode of alternative electricity generation available in the market: diesel generator sets. Figure 10 seeks to determine the diesel consumption of telecom industry by charting the tower distribution and the availability of grid power in their specific region.

Figure 10: Tower Distribution[15]

Sources: Press releases, EAI Analysis



1.3 The Diesel Conundrum

Diesel is versatile oil: its function varies from being used as a transportation fuel to helping in power generation in industries and agriculture. It has had one of the highest growth rates in demand among petroleum products in India. A combination of subsidized prices, acute power shortage and soaring petrol prices has set the demand for the fossil fuel sky high. The growth in demand for diesel was pegged at 12 per cent for FY 2012, while the corresponding figure for petrol was 4.9 per cent .The overall demand for petroleum products increased by 4.9 per cent and diesel's share in this petroleum-products basket increased to 43 per cent from 35.32 per cent in 2006-2007, showing the economy's dependence on this crude product.

Diesel is a regulated commodity in India, that is, the Government of India sets a ceiling on the selling price of the fossil fuel. India imports 80 per cent of its crude oil and the price of crude is a major component of the production cost of diesel. But while crude prices have dipped and soared over the last few years, diesel prices in the country have only witnessed a marginal increase.

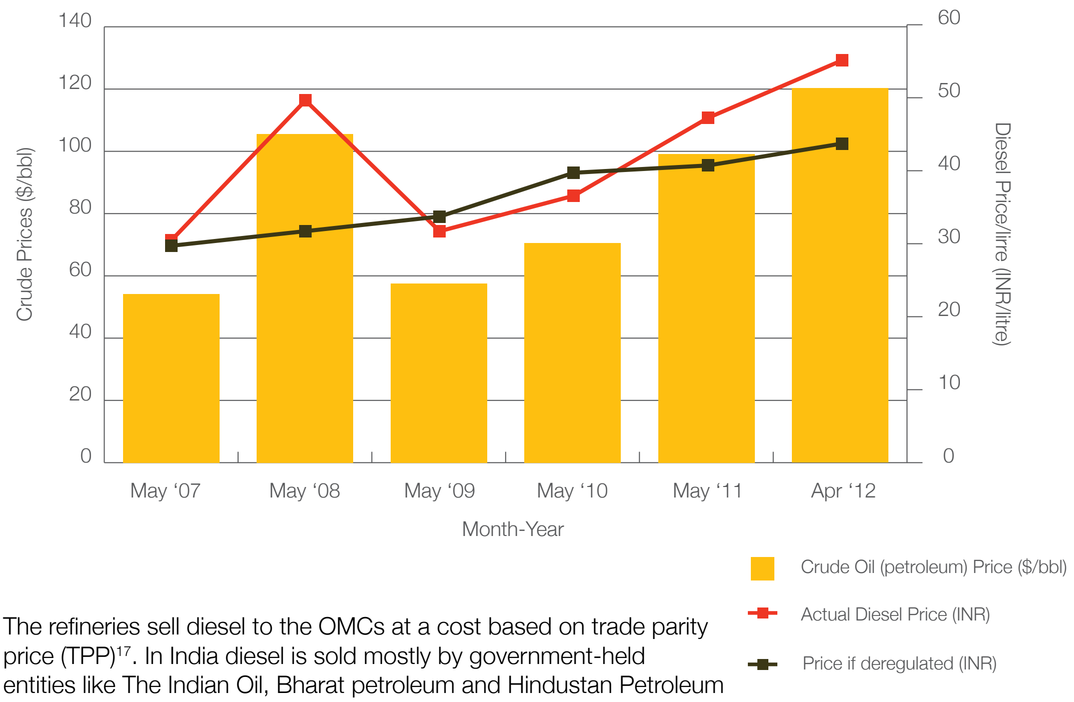
[14]Source: CEA

[15]Sources: Press releases, EAI Analysis, Market Data; For all practical purposes, distribution has been taken as 20% in rural areas with average grid availability of 4 hours, 50% with availability of 12-14 hours and 30% with availability of 18-20 hours.

The Indian crude basket is a mixture of the Dubai-Oman Sour Crude (Fateh) and Brent Sweet (Dated) barrels, with the ratio in favour of Fateh. The petroleum ministry perform an analysis of what diesel prices should be at the local level if they were to reflect the prices (adjusted prices) at which they are imported by the refineries. The following figure compares this adjusted price to the actual price and the global crude price for the Indian basket.

Figure 11: Comparison Of Market Prices If Diesel Were Deregulated Against Prevalent Prices[16]

Sources: Petroleum ministry “Report of the Expert Group on a Viable and Sustainable System of Pricing of Petroleum Products”, EAI analysis



The refineries sell diesel to the OMCs at a cost based on trade parity price (TPP)[17]. In India diesel is sold mostly by government-held entities like The Indian Oil, Bharat petroleum and Hindustan Petroleum Corporations (the OMCs or Oil marketing companies).The difference between the two (actual and adjusted prices in the above figure) would represent the under-recoveries of OMCs over the last few years. The OMCs are forced to sell the diesel at subsidized prices to the dealers for which they are compensated by the Government at a later date. This compensation covers the difference in the cost price (TPP) and selling price and does not include OMC margins and taxes. The extent of government subsidy is highly variable depending on budgetary allocations. A summary of the burden on the government as a result of price regulation is provided in the figure below. The government of India has so far spent at least INR 74,000 crores ($14.8 billion) in the form of compensation for the under-recoveries reported by the OMCs. Most of this compensation is in the form of oil bonds that the government issues to the OMCs. While this (the issuance of oil bonds) will not add to the deficit at this point, the burden on the government at the time of redemption (when the bonds mature, the government will have to pay up the amount) will be huge and it will leave a big hole in India’s pocket. Earlier, in June 2010 the Empowered Group of Minister’s (EGoM) decided in-principle to deregulate diesel prices, which causes 40 per cent of these losses or under recoveries.

“Currently, the public sector oil firms - Indian Oil, Hindustan Petroleum and Bharat Petroleum are currently bleeding INR 13.65 per litre on diesel.”

Currently, the public sector oil firms - Indian Oil, Hindustan Petroleum and Bharat Petroleum are bleeding with a loss of INR 13.65 per litre on diesel[18].

[16]Sources: Petroleum ministry “Report of the Expert Group on a Viable and Sustainable System of Pricing of Petroleum Products”, EAI analysis

[17]Trade parity price is calculated as the sum of 80% import parity price (IPP) and 20% of export parity price (EPP). Export and Import parity prices are those that exporters receive and importers pay in international markets when they sell and buy one litre of diesel respectively

[18]http://profit.ndtv.com/News/Article/oil-firms-bleed-no-diesel-price-hike-in-sight-308697

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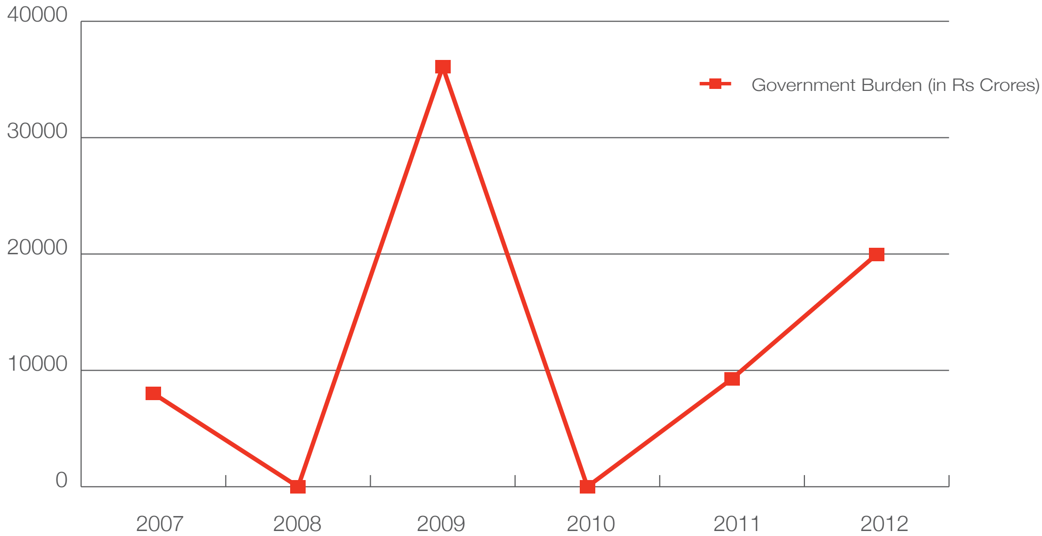
1.3.1 The telecom perspective

We mentioned earlier in this report that telecom sites present in areas where the grid was unavailable or unreliable had to go for diesel generators. With at least 15 to 20 per cent of the sites situated in completely off-grid areas and another 50 per cent present in areas where the grid is only available for anywhere between 6-14 hours (and unreliable at that) diesel generator sets are a regular part of the landscape. An estimated **3.2 billion**[19] litres of diesel was consumed by the telecom industry last year. It's important to mention here that the telecom industry is the single largest consumer of diesel after the Indian railways and probably the biggest beneficiary of the subsidy that is given to users of fossil fuels.

With another 1, 00,000 towers on its way, the telecom industry will not only push up the demand for diesel and further burden the government but also will be responsible for nearly **8.4 million tonnes of carbon di-oxide emitted into the atmosphere**[20].

Figure 12: Government Burden As A Result Of The Diesel Subsidy[21]

Sources: Press releases, PPAC, EAI Analysis



2-Trade parity price is calculated as the sum of 80% import parity price (IPP) and 20% of export parity price (EPP). Export and Import parity prices are those that exporters receive and importers pay in international markets when they sell and buy one litre of diesel respectively

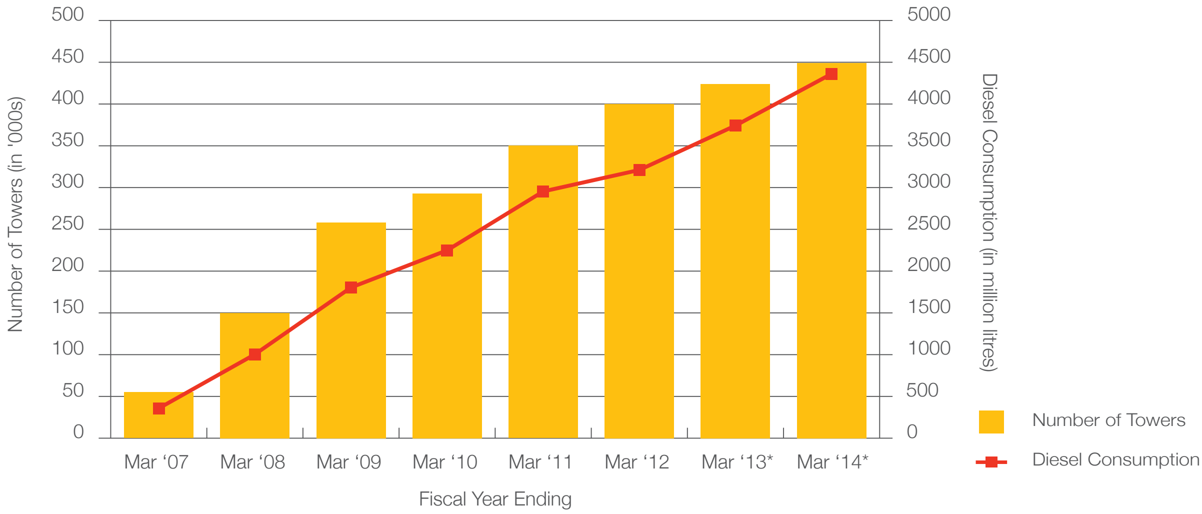
[19]Refer Annexure for assumptions and methodology

[20]1 litre of diesel emits 2.63 kg of Carbon di-oxide when burnt

[21]Refer Annexure for details, Sources: Press releases, PPAC, EAI Analysis

The growth in consumption of diesel and the corresponding carbon emissions is charted below.

Figure 13: Figures For The Rise In Diesel Consumption With The Increase In Towers[22]
Sources: PPAC, TRAI, Press releases, EAI Analysis



1.3.2 Economics of power production from diesel

The use of diesel to produce electricity is not a new concept. Diesel is fed into an internal combustion engine that converts the heat energy obtained from burning the diesel to mechanical energy, which in turn is converted to electricity by a generator. A litre of diesel produces about 10 kWh of energy but due to conversion processes, only 35-40 per cent of it can be recovered in the form of electricity.

The cost of generating one unit of electricity comes to about INR 14-15[23] if we take the current market (read controlled) rate of INR 45/litre of diesel. There was no cause for worry as long as the cost of producing electricity from diesel was lesser than the additional revenues received from expansion into off-grid areas. But it was soon discovered that there were a multitude of problems associated with using diesel generators.

After all the factors for using a diesel generator to produce electricity by the telecom industry are considered we find that the economics take a severe beating. In some cases the cost of producing one unit goes up to INR 60 and more. The various factors that contribute to this high cost are discussed below.

1.3.2.1 Pilferage

Diesel is a valuable commodity. With telecom towers often being situated in remote areas with very little supervision, one of the biggest problems operators and tower companies faced was the theft of diesel. It wasn't unusual for 20-30 per cent[24] of the diesel to be unaccounted for. In some areas, pilferage is estimated to be as high as 50-60 per cent[25].

This has contributed to the high cost of a unit of electricity generated from diesel.

[22]Sources: PPAC, TRAI, Press releases, EAI projections
[23]If price of diesel is Rs. 45/litre and each litre produces 3.4-3.5 units, assuming very little maintenance cost, no pilferage and zero transportation costs
[24]Industry interviews
[25]Industry interviews

1.3.2.2 Inefficient loading

The ground-based telecom towers are built to accommodate up to 4 tenants, which decreased when the tenancy rate increased. The operators at times procured 15 kVa diesel generator sets even when the site had only 1 tenant. A diesel generator's fuel consumption increases by 15-20 when the load level is below 50%. For instance, a standard Cummins 15 kVa generator consumes about 3.52 litres running at full capacity. However, when the load is reduced to 50%, one might expect the diesel consumption to be near 1.76 (50% of 3.52)[26] but the actual consumption is between 2.1 to 2.2 litres, sometimes 2.3. As the load levels go lower, the variation increases causing consumption levels to go up precipitously[27].

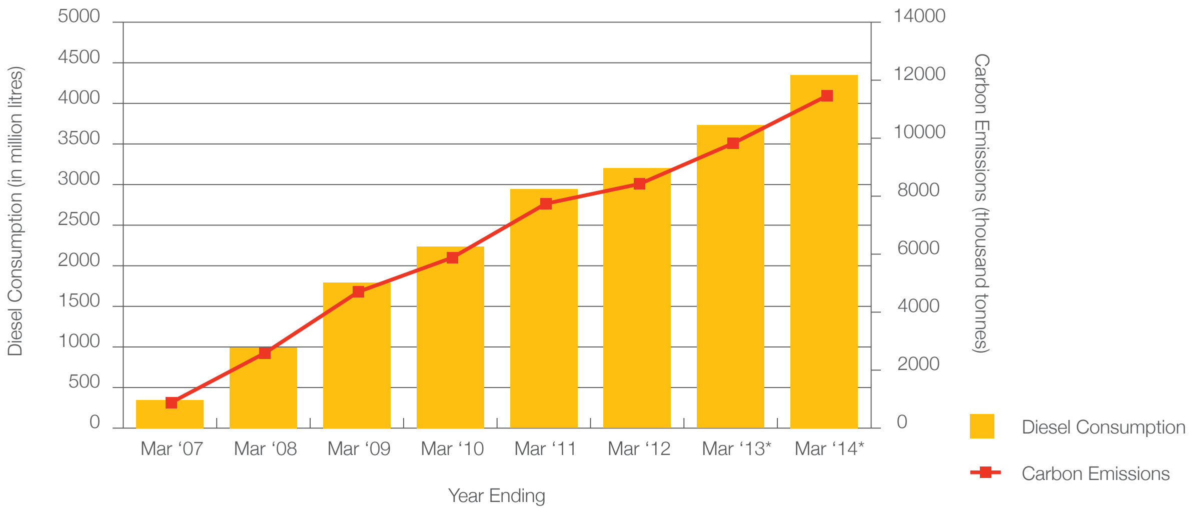
1.3.2.3 Transportation Cost

Usually the transportation cost of diesel fuel is negligible at high volumes. But this argument dissolves if the towers are situated in far-flung areas. Transportation costs go up to Rs 2/litre, adding 4 per cent to the cost of every litre consumed.

The breakup of diesel costs for a 1 kW site is provided in the figure below. Diesel inefficiencies account for the maximum percentage of the costs at this load level. The assumption is that a 15 kVa generator is used and that the diesel price is at INR 45.

Figure 14: Carbon Emissions At The Respective Diesel Consumption Levels[28]

Sources: PPAC, TRAI, Press releases, EAI Analysis



1.4 An Unsustainable Diesel Economy

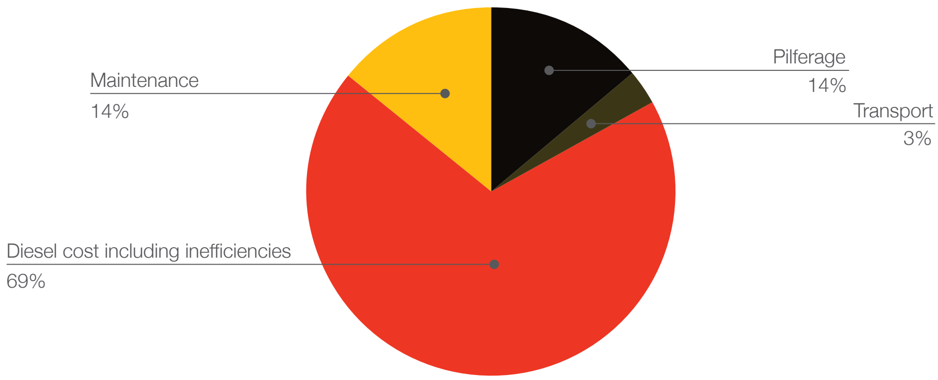
Factors such as pilferage and inefficient loading, which increase the diesel consumed by 20-25 per cent, not only impose unnecessary additional cost pressures on the operators and raise the burden on the government but also cause environmental hazards.

In recent years the telecom industry has repeatedly come under fire for the billions of kilograms of carbon emissions that it emits every year. It has also been opaque about its carbon footprint despite consuming huge amount of energy. The carbon di-oxide emission level is not the only unsustainable factor. The problems related to its dependence on diesel subsidies are addressed next.

[26] Cummins website
[27] Refer annexure to footnote 18
[28] Sources: PPAC, TRAI, Press releases, EAI Analysis

Figure 15: Breakup Of Diesel Costs For A 1 Kw Site[29]

Sources: EAI Analysis



1.4.1 Imminent Rise in the price of diesel

It is plausible to expect the government to deregulate diesel on a preferential basis, if not completely. Deregulating diesel could cause an instant jump in the price of diesel by 10-15 per cent. Since fuel plays a vital role in the transportation of most items in the consumer basket, any sudden jump in its price would lead to compounding effects on the consumer price index and send inflation through the roof. It is a risk that the government is unwilling to take as the inflation has already touched dangerous levels and threatens to stop India's growth story in its tracks. But on the other hand, to continue to subsidize diesel puts downward pressure on the fiscal deficit, which the government struggles to get a grip on. These points make a strong case for a preferential subsidy system but this will disrupt the telecom sector.

If and when deregulation of diesel happens, which is quite possible, it is safe to assume that the prices of crude oil will head northwards. To continue to depend on diesel could cripple the telecom sector. It shall have a cascading effect on the end users (it would lead to an increase in tariffs or companies going out of business) and all sections of society in this increasingly mobile- phone dependent economy will be at risk. Cutting down on diesel consumption seems to be the only solution.

In the next part of the report we look at alternative sources of energy. Apart from ensuring a sense of energy security, it shall help to wean the telecom sector away from diesel.

[29]Sources: Industry Inputs, EAI Analysis

Diesel Generator
© Sharbendu De / Greenpeace

PART II

THE PATH TO A DIESEL-FREE TELECOMMUNICATION

THE PATH TO A DIESEL-FREE TELECOMMUNICATION

2.1 Green Telecom: An Introduction to the TRAI directive

In January 2012, the Telecom Regulatory Authority of India (TRAI) recognised the importance of sustainable telecom growth and issued a directive to all the telecom operators.

The directive calls for retroactive implementation of renewable energy technologies and energy efficiency measures. Operators are also required to declare their carbon footprint bi-annually. This step taken in the wake of the ever increasing diesel consumption levels, despite the wide range of energy efficiency measures & alternate energy options available to the telecom industry worldwide and the mounting pressure on the corporate sector to take sustainability seriously in the view of the dangers of climate change threatening one and all.

The directive followed the "Approach to green telecom" paper released by TRAI in 2011. This paper was drafted after consultation with stakeholders and was the first step to reduce carbon footprint of the Indian telecom sector.

TRAI estimated that the telecom network in India was responsible for nearly 16 million tonnes of carbon di-oxide emissions that represent about 1 per cent of total Indian GHG emissions. While this is not an eye popping figure, the regulator recognizes that the sector would continue to add subscribers and expand into rural areas through the decade.

The adoption of renewable energy sources and optimization of network energy consumption, with a view to cut the base load energy requirements, was also deliberated by industry participants. If adopted these methods could cut the power required by BTS equipment by nearly 40-50 per cent.

"The close correlation between energy saving and money could motivate the corporations and business entities to pay more attention to their energy consumption, and work towards its reduction!"

The demand from 4, 00,000 telecom sites as of March 2012 is over 1700 MW[30]; the towers in rural and suburban areas demand more than a two-third of this number. These demands are being met by diesel generators presently. By 2020, this requirement will almost double to 2500 MW. The JNNSM (Jawaharlal Nehru National Solar Mission) and MNRE (Ministry of New & Renewable Energy) envisage an addition of 2000 MW of decentralized solar capacity with another 2000 MW as an aspired target (total 4000 MW) by 2022.

But the fact is that more solar energy needs to be tapped to generate the same amount of electricity. This is due to the aspect of current capacity utilization factor (CUF) for a solar unit, which is around 15 per cent for small systems. This equates to around 6.2 MW of solar needed to cater to a 1 MW load. If we extend this calculation to our telecom case we find that around 15,500 MW of solar will be required to cater to 2500 MW of load demand.

The JNNSM makes a provision of 2000 MW for all decentralized applications. By our estimations even if 1000 MW of this goes to the telecom cause, there still needs to be an addition of 14,500 MW. Clearly, there needs to be greater ambition to support the use of renewable energy technologies in this sector.The TRAI directive is clear on the sources of

[30] 15 billion units of electricity at 24 hours a day, 365 days a year translates to about 1710 MW

energy and on the upper limit of carbon emissions but does not details the level of network operational efficiency. Besides, it does not mandate a reduction in direct diesel consumption itself.

In fact, it directs operators to adopt a voluntary code that includes various methods to optimize their power consumption. Methods to optimize energy consumption to reduce load demand and the green technology options available to cater to this demand are discussed in subsequent sections of the report.

2.2 Energy Efficiency: The First Step

Energy efficiency is the "flavour of the day". With industries increasingly coming under fire to accept responsibility for their environmental footprint and being forced to look at long term sustainability, energy efficiency has fast gained traction as a low hanging fruit with fast and tangible benefits. Three easy ways have been accepted to lower the carbon emissions and cut costs: conducting an audit to understand the energy dynamics of a system, using low energy consumption products and reducing energy wastage.

The close correlation between energy saving and money could motivate the corporations and business entities to pay more attention to their energy consumption, and work towards its reduction!

The principle behind it is to first reduce the amount of energy required for the system to operate without compromising on capability. And then think about alternative energy options to minimize the overall carbon footprint.

Now we shall discuss energy efficiency options that have emerged in the telecom sector over the last few years, with a specific focus on GSM systems.

2.2.1 The Telecom Perspective

The approach to design an energy efficient system has to be from bottom up. For example in 2008, a leading equipment manufacturer 'Alcatel-Lucent' claimed that they could effectively reduce the number of BTS sites needed to cover a particular area by almost 50 per cent[31].

The telecom equipment manufacturers have constantly innovated to reduce the pressure on operators to consume less energy. Due to their effort numerous low energy consuming telecom equipment products with BTSs capable of functioning at temperatures of 55 C have hit Indian market. Such products eliminate the requirement of shelters and air conditioners.

Besides, power consumption of the BTS itself has almost halved. For example, a 2 x 2 x 2 BTS power consumption has dipped from 1.3-1.4 kW to about 700-800 watts and for a 4 x 4 x 4 BTS from 2 kW to 1.283 kW. TRAI called for a reduction to 500W by 2020 in its paper "Approach to green telecom".

A major chunk of the energy goes towards cooling the BTSs (in the use of air conditioners) at the indoor sites. At the outdoor sites it goes to a combination of RF & power amplifiers and signal processors.

It would be helpful to look at the measures taken by operators in advanced markets in energy efficiency, as it is now a global movement. European countries like Germany, Italy and others are already aggressively working towards the reduction of carbon footprint from the entire ICT industry.

We shall attempt to explore some of these solutions, which could enable operators to reduce their energy consumption.

[31]http://www.mobilontelecom.com/Lucent-Energy-Efficiency-White-Paper.pdf

2.3 Air Conditioning

More than half of India's tower sites have indoor shelters with BTSs. These old generation BTSs have low optimal operating temperatures and require air conditioning for smooth operations.

Although the air conditioners in the market boast of high efficiency, they often impose a higher load than the BTSs themselves. This is a prospective area for improvement and savings.

2.3.1 Climate Control and Free Cooling Units

Such solutions could find more usage for legacy sites which still house older BTS's. The newer generation BTSs as discussed before has higher operating temperature and don't need air conditioners.

Different ways to solve the air conditioning problem in older BTS's:

- Firstly, by turning on the air conditioner only when the BTS needs cooling. This active monitoring of the BTS would reduce the energy consumption by an estimated 3-4 per cent.

- Secondly, the need for air conditioners can itself be monitored with sophisticated technologies like free cooling :

1. Air Economizers.

It's like opening a window when it's hot inside and cool outside. This technology makes use of low ambient temperatures outside the shelter, optimally between 21-25 degrees Celsius, to cool an enclosed space at a higher temperature. Thus utilizing the available cool ambient air. Whenever the ambient temperature allows, free cooling mode is activated and the air-conditioning units are switched off.

By implementing such solutions any operator can reduce up to 90 per cent[32] of the effective energy consumption, depending on the climate condition of the site. Thus cutting drastically the overall operating costs taking the large number of Base Stations in operation[33].

Free cooling implementation by Bharti Infratel and has been proved to have significant savings potential. FCUs consume about 200-300 W, which is 5-6 times lower than 0.9 ton air conditioners that require about 1000-1100 W. Furthermore, they can run from a battery source unlike an air conditioner.

2. Water Economizers:

This draws water at lower temperatures from a nearby available source (typically lakes, ponds or rivers) and use blowers to pass air through cold water into an enclosed space that requires cooling. But this application is at the R&D stage and has not been practically utilized commercially in India[34].

2.4 Power Amplifiers and RF Equipment

The telecom traffic is lowest between midnight and 5 am on a normal day. It is estimated that the network traffic drops by at least 30 per cent during these hours. A study performed by ZTE, a leading Chinese telecom equipment manufacturer, explores new avenues to reducing power consumption.

Power amplifier consumes the maximum power among the network components. The study

[32]http://vodacom.com/pdf/innovation_tour_guide.pdf
[33]http://www.stulz.cn/en/products/telecom-cooling/free-air/
[34]http://www.tranehk.com/eng_news/vol37_3.pdf

proposed several energy saving solutions; some require software modifications while others need an up gradation to newer generation devices.

It was observed that, even without input signals the power amplifier (PA) draws static current. The solution offered was to turn off the PA bias voltage when there are no RF signals during these timeslot. Again it can be turned back on when there is an RF signal.

In an another innovative proposal, Nokia Siemens another leading equipment manufacturer proposed to modify BCCH[35] transmissions to save energy. According to the proposal software designed specifically for this purpose identifies periods of low traffic and sends the BCCH dummy bursts at lower power levels.

Although the software for implementing the above two solutions would entail capital expenditure, the payback period expected are less than two years.

"The telecom traffic is lowest between midnight and 5 am on a normal day. It is estimated that the network traffic drops by at least 30 per cent during these hours."

Losses also occur in a base site during the transmission of RF signals through feeder cables. Placing the RF equipment at the top of the tower, near the antenna, eliminates these losses and increases the BTS output and improves the overall energy efficiency by over 10 per cent. TRAI suggested the integration of antenna with RF equipment in order to cut down on transmission losses.

Passive infrastructure sharing involves the sharing of auxiliary components such as power supply equipment, tower structure space, shelter cabinets, cables etc. Active sharing entails using each other's antennae, backhaul transmission system, base station equipment i.e. components of the core network.

Active sharing has been estimated to cut down network costs by an additional 40 per cent over the available savings from passive sharing. It results in a lesser requirement for towers, lesser generator sets and installed telecom masts.

2.5 Power Supply

- Rectification

There is always some energy lost in rectification because the grid supply is usually in the form of AC. While the rectifiers of the previous generation offered 90-91 per cent efficiencies, ones in the market today offer close to 96 per cent. Replacing the older rectifiers with the new and more improved versions will yield significant savings in the long term and significant emission reduction from DG sets.

- Intelligent Charging of batteries

Renewable energy technologies [RET] or non-renewable energy sources both as the sources of power in grid deficit places could be used to charge batteries. The stored up charge in the battery is then used to offset diesel generator set time and thus help in reduce excessive dependence on non-renewable . The solution optimizes the operation of battery and Grid power effectively.

In this, the system defines the priority of the sources to work or provide the power to the telecom equipment, so as to reduce the carbon emission and operational expenses of telecom site.

When grid power is unavailable, the battery bank which has been charged by the grid and the available RET takes over to power the BTS. Meanwhile it keeps track of the battery's state of charge (SoC) while controlling the cycles between the renewable energy sources and batteries.

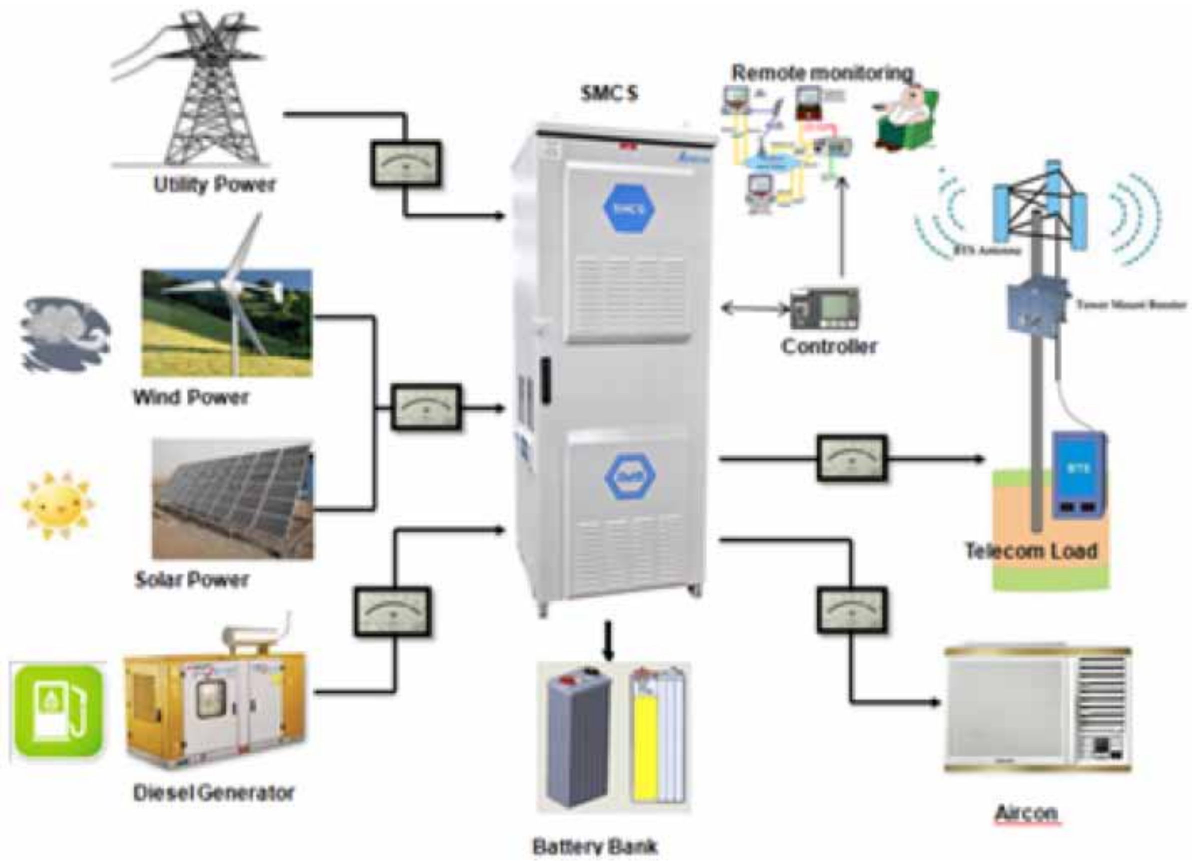
Once a certain discharge level is reached, this smart energy system switches the mode of supply to the available power source. This intelligent charge controller operates with the help of a bi-directional inverter that detects the charge of the battery and diverts the primary power

[35]Broadcast control channel

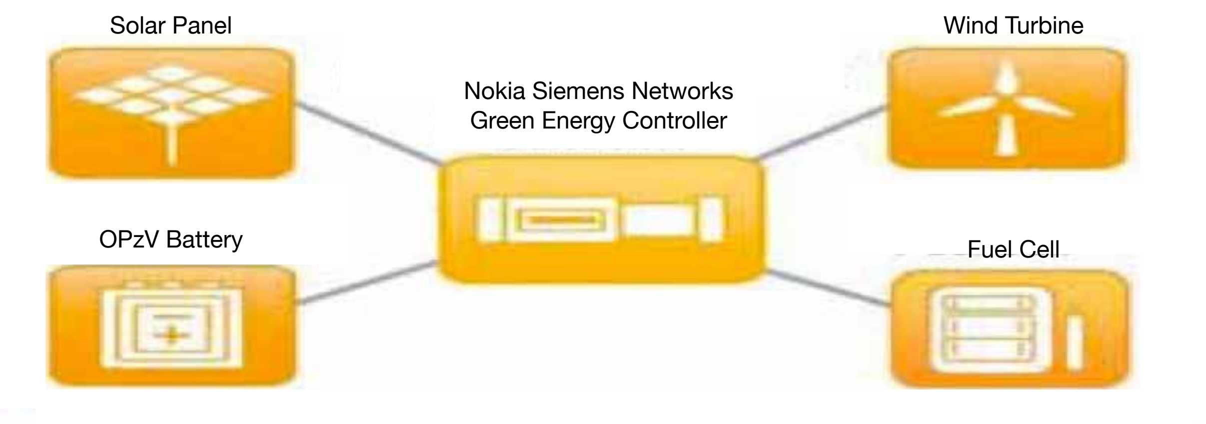
source, towards charging it fully. It could also be designed to protect the batteries from overcharging.

The potential for savings with this system is quite high. A fully integrated power management system is the key to significant operator savings and emission reduction from DG sets.

Telefonica Germany, one of Germany's biggest operators, is expected to save close to $500,000 and 2 GWhs of energy and mitigate carbon emissions by 1 Kiloton after installing a smart energy control system and high efficiency rectifiers[36].



Source: Delta India Electronics[37]



Source: Nokia Siemens Networks Green Energy Controller

[36]http://www.greentelecomlive.com/2012/04/11/telefonica-germany-sees-e1-8m-annual-savings-from-energy-efficiency/

[37]http://www.deltaelectronicsindia.com/tps_smcs_renewable_hybrid_solution.aspx

2.6 Use of DCDG

In the current scenario, inefficient loading of generators is one of the biggest inefficiencies in a telecom system. It can cause up to 80 per cent excess diesel consumption leading to higher maintenance costs, purchase costs and frequent breakdowns[38] and higher emissions.

One possible solution is the use of variable speed DC diesel generators (DCDG). DC generators work on the same principle as an AC generator but in the presence of an internal battery.

In such cases, the generator can run at near full capacity and at the same time charge its batteries. Thus securing an alternate power source for the load and eliminating the problem of running the generator at lower capacities.

2.7 Network Planning

Apart from the above measures, proper network planning will also play a big role in keeping the carbon footprint of the telecom industry low. Infrastructure expansion in the coming years would mostly be in rural areas, with marginal additions expected in urban regions.

By equipping rural areas with low capacity and high coverage devices, the expansion of the network would occur with very low energy consumption. For urban areas, towers should be planned in green buildings to eliminate the necessity for air conditioning. While low energy consuming devices can be used for indoor coverage, high capacity systems capable of being integrated with renewable energy sources can be used for outdoor coverage.

The above solutions can reduce the power consumed by 30-50 per cent[39], save billions of units of energy and reduce the carbon emissions by the order of several million tonnes.

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Low power roof top mini mobile tower powered by solar energy. This tower called as World GSM, world's smallest mobile tower, is developed by Vihaan Network Limited (VNL).

More importantly an energy-efficient system brings down the load requirement. It cuts costs and makes the case for renewable energy deployment MUCH stronger. Indeed, the combination of energy efficiency and renewable energy installations can help achieve a zero-diesel telecom industry.

[38]Industry Interviews
[39]Industry Inputs, EAI Analysis

2.8 Climate change threats

The threat of climate change caused by rising global temperatures is the most significant environmental challenge that the world faces today. It has major implications for the world's social and economic stability, its natural resources and the way we produce our energy. In order to avoid the most catastrophic impacts of climate change, the global temperature increase must be kept as far below 2°C as possible.

Even a 1.5°C warming has had many fall outs like increase in drought, heat waves and floods; along with increased water stress for up to 1.7 billion people, wildfire frequency and flood risks in many regions.

Time is running out, but it is still possible to keep the temperature within limits. For this global greenhouse gas emissions will need to peak by 2015 and decline rapidly after that, reaching as close to zero as possible by the middle of the 21st century.

If rising temperatures are to be kept within acceptable limits then we need to significantly reduce our greenhouse gas emissions. The expert consensus is that this fundamental shift in the way we consume and generate energy must begin immediately and be well underway within the next ten years in order to avert the worst impacts of climate change[40].

"Time is running out, but it is still possible to keep the temperature within limits. For this global greenhouse gas emissions will need to peak by 2015 and decline rapidly after that, reaching as close to zero as possible by the middle of the 21st century. "

The aspiration towards reduction in emission from telecommunication network in India can make a significant contribution towards this mammoth task for humanity.

Especially when it makes absolute economic sense. Also, enabling India's commitment to reduce its emissions intensity of its GDP by 20-25% by 2020 in comparison to the 2005 level.

2.9 Renewable Energy Technologies

Switching from fossil fuels to renewables offers substantial benefits such as independence from world market fossil fuel prices and the creation of millions of new green jobs. It can also provide energy to the two billion people currently without access to energy services.

Globally as per Greenpeace's own Energy revolution scenario[41], renewable energy capacity at the end of 2010 was 197 GW, while at the end of 2011 it was 237 GW. Between 2000 and 2010, 26 per cent of all new power plants worldwide were renewable powered, mainly dominated by wind.

Renewable energy technologies have already overtaken conventional sources of energy not just because they are sustainable and carbon emission-free but also because they are economical. Wind and biomass having already reached grid parity in India and solar has breached the INR 8 mark in the last reverse bidding auction. The stage is all set for them to overtake their conventional counterparts in terms of capacity addition. Under such scenario, solar will achieve retail grid parity in India by 2014/15 and wholesale grid parity by 2018/19.

2.9.1 Investment in Renewables

In 2011 alone, investments in India's renewable energy markets rose to approximately INR 51,000 crore ($10.3 billion)[42], with more than one-third of the investments directed at solar projects. Investments are expected to double for Phase 2 of the National Solar Mission.

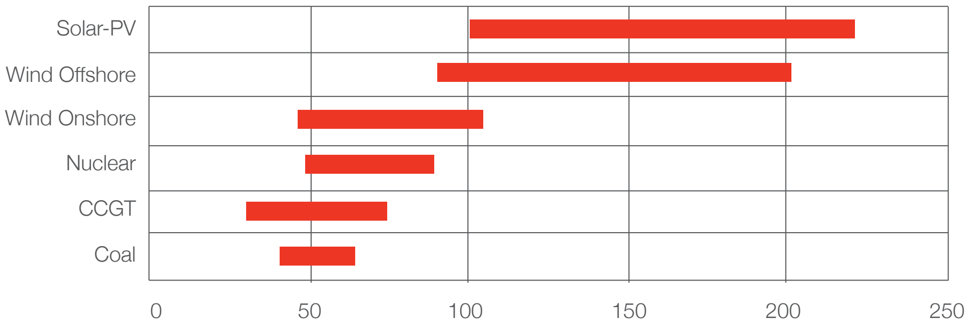
In terms of HSBC's analysis, global investment in clean technology in 2011 was USD 260 billion. During the same year India's own clean tech investment was USD 10 Billion. For India this was a record growth of 50 per cent over 2010.

[40]IPCC – Special Report Renewables, Chapter 1, May 2011
[41]http://www.greenpeace.org/international/energyrev2012/
[42]2011 Worldwide Renewable Investment

The Bank confirmed that in 2011, over 40 GW [+ 14 % YOY] of wind turbines and over 25 GW [+40% YOY] of solar were installed globally. For the first time clean energy investment outstripped investment in fossil fuel power plants. HSBC also predicts that by 2020 India will continue to be among the top wind base and 6th largest solar base in the world.

The below graphs from HSBC show where generation costs were in 2011 and where they are heading. The graph shows the estimated range of power generation costs (in Euros) for 2011.

Estimated range of power generation costs in key markets for new capacity added during 2011/2012e (EUR/MWh)



Source: HSBC estimates

2.9.2 From the telecom perspective

With TRAI mandating a compulsory mix of renewables by 2015 and setting targets for 2020, the telecom companies have to start introducing renewables into their electricity mix to power their network infrastructure.

In the telecom context looking at renewables makes a lot of sense considering that the cost of producing a unit of electricity from diesel theoretically is in the order of INR 22-27. Solar has already become competitive for electricity penetration from Diesel in India.

The costs of backup power (diesel) are so high that even newer technologies such as fuel cells have started making economic sense.

Idea Cellular has launched pilot projects to test fuel cells as a source of backup power in their quest to eliminate diesel and reduce network costs.

Wind is slowly evolving into a technology preferable for hybrid telecom tower application. Operators like Bharti has already launched hybrid pilots based on small wind turbines. With the rapid strides they have made over the last few years and the amount of R & D money going in, it's only a matter of time before it becomes a preferred solution for the telecom industry too.

2.9.3 The Urgency

As per Bell Labs currently every operator on the planet is challenged by the rising operational and cash expenses, 70 per cent of these are from electricity. In view of this prevailing situation a switch to renewable energy sources and an intellectual investment in green technologies will surely add economic robustness and long-term profitability for telecom Industry.

However, there are a few critical criteria that renewable energy technologies would have to satisfy before it becomes a reliable and primary source of power for the telecom industry.

TRANSITION HAS ALWAYS BEEN THERE!

- From Analog to Digital
- From Circuits to Packets

2.9.4 Criteria for the Telecom Industry

Quality of Power

The telecom industry has one of the highest uptime requirements (99.999999%) for continuous and reliable power. The operators in the telecom industry would consider a solution that does not bring down their quality of service and losses of revenue. Even a minute of downtime results in revenue losses in the order of tens of crores.

Savings in Operational Expenditure

The operational expenditure involved with any renewable energy system must be lower than that of the power source it replaces. This is one of key metrics that operators will look into as it will drive the return on investment, payback period and hence the economic feasibility.

Scalability

The telecom industry is poised for a massive expansion over the course of the next few years. Operators would look to reduce their costs of expansion as much as possible. This will be by occupying more towers that have already been constructed and construction of new towers in new places of expansion. The source of power will have to be scalable to accommodate this expansion.

Payback period

This is inter-linked with savings in operational expenditure. The savings in operational expenditure will play a crucial part in determining the payback period. The higher the savings and lower the capital cost, lower will be the payback period.

Capital Costs and Incentives

Although some business models like the Renewable Energy Service Companies might not require operators to make upfront payments, lower capital costs drive adoption. Incentives play an important part in reducing overall costs and expediting payback. Currently incentives are offered only to solar under the JNNSM among the different renewable energy technologies.

Supply chain and Ease of Operations

Operators would prefer not to worry about supply chain and ease of operation for power sources if their operations are smooth. However the scope of their business depends on it. Hence, any kind of adaptable renewable energy technology for telecom must have a secured supply chain.

Other Benefits

Renewable energy technologies which have a low carbon footprint have huge social and environmental benefits. It would not only contribute to the "green" image of the company but would also help in terms of ensuring energy security. It could also be a way for telecom companies to fulfil their Renewable Purchase Obligations (RPOs).

Based on these basic criteria, we will now explore the various alternative renewable energy technologies in the following part of the report.

2.10 Alternative Energy Options

There are many sources of energy that are renewable and can act as an alternative to conventional energy sources like oil and coal. These sources of energy are harnessed by natural processes, provide an alternate 'cleaner' source of energy and help to negate the effects of GHG emission. These power generation techniques can be described as renewable because they do not deplete any resource to create the energy.

While there are many large scale renewable energy sources, we will look at renewable energy technologies and their viability in the telecom context:

2.10.1 Solar

There is enough solar radiation available all over the world to satisfy a vastly increased demand for solar power systems. The sunlight which reaches the earth's surface can provide 7,900 times more energy than we currently use. Each square meter of land is exposed to enough sunlight to produce 1,700 kWh of power every year.

India, a tropical country, has huge potential for solar power generation. It receives 5,000tn kWh per year according to government estimates, with most parts receiving 5-7 kWh per square metre per day. Solar energy potential seems infinite in this country and if cost economics work out it can be tapped to meet our needs. Here is an interesting statistic: *a square piece of land (55kmx55km) in the desert of Rajasthan can be tapped to generate enough solar power to equal the existing power generation quantum in India*[43].

"A square piece of land (55kmx55km) in the desert of Rajasthan can be tapped to generate enough solar power to equal the existing power generation quantum in India."

2.10.1.1 Technology

Photovoltaic (PV) technology is the generation of electricity from light. Photovoltaic systems contain cells that convert sunlight into electricity. Inside each cell there are layers of a semi-conducting material. Light falling on the cell creates an electric field across the layers, causing electricity to flow. The intensity of the light determines the amount of electrical power each cell generates. A photovoltaic system does not need direct sunlight in order to operate. It can also generate electricity on cloudy and rainy days but with lower output.

The most important parts of a PV system are the cells which form the basic building blocks, the modules which bring together large numbers of cells into a unit, and, in some situations, the inverters used to convert the electricity generated into a form suitable for everyday use.

There are several different PV technologies and types of installed system. PV systems can provide clean power for small or large applications. They are already installed and generating energy around the world on individual homes, housing developments, offices, public buildings and telecom network towers!

Today, fully functioning solar PV installations operate in both built environments and remote areas where it is difficult to connect to the grid or where there is no energy infrastructure. PV installations that operate in isolated locations are known as stand-alone systems.

Modern PV systems are not restricted to square and flat panel arrays. They can be curved, flexible and shaped to the building's design. Innovative architects and engineers are constantly finding new ways to integrate PV into their designs, creating buildings that are dynamic, beautiful and provide free, clean energy throughout their life.

2.10.1.2 Stand-alone, off-grid systems applications

Off-grid PV systems have no connection to an electricity grid. An off-grid system usually has batteries, so power can still be used at night or after several days of low sun. An inverter is needed to convert the DC power generated into AC power for use in such application.

Off-grid industrial systems are usually used in enabling traffic signals, marine navigational aids, remote lighting, highway signs and water treatment plants among others. Off-grid systems are also used in bringing electricity to remote areas. Such systems provide enough power for several homes, a community or small business use.

However, the most important application are powering mobile network towers and repeater stations, enabling telecommunication even in far off grid places. Both full PV and hybrid systems are used in this case.

[43]http://www.kpmg.com/IN/en/IssuesAndInsights/ThoughtLeadership/The_Rising_Sun_full.pdf

Solar grid power system, ALTA Energy
© Vivek Muthuramalingam / Greenpeace

Hybrid systems are powered by the sun when it is available and by other fuel sources during the night and extended cloudy periods. Off-grid industrial systems provide a cost-effective way to bring power to such an application in areas that are remote from existing grids.

2.10.1.3 Key driver

At the end of 2011, the installed solar Photovoltaic (PV) technology capacity touched 300 MW. By May 2012, this figure had increased to over 800 MW clocking a growth rate of 170 per cent in just 6 months. Buoyed by the National Solar Mission (JNNSM) and aggressive state policies from Gujarat and Rajasthan, a steep growth is expected in terms of capacity addition over the next few years.

Apart from aiming to add 20 GW of grid-tied solar power by 2022, the Ministry of New and Renewable Energy (MNRE), under the JNNSM, has also targeted an addition of 2000 MW in the form of decentralized solar systems [off-grid] and has an additional aspiration target of 2000 MW.

Under the same policy and certain conditions, the MNRE provides subsidies @ INR 81/Wp to offset the capital cost of the project. The MNRE recently revised this capital subsidy and benchmark cost of SPV systems last year on April 1, 2011[44]. In today's scenario India's total solar installations is expected to expand from 54 MW in 2010 to more than 9,000 MW in 2016[45].

These processes indicate a positive trend towards cost reduction. From 2005-2011 itself, solar modules cost and generation cost have fallen by over 60 per cent. The costs will fall with technological advancement and growing indigenization.

2.10.1.4 Looking through the Telecom

A number of factors come affect the viability of solar in the telecom sector. First, the technical viability needs to be assessed, followed by a careful cost-benefit analysis. The strongest point in favour of solar on a macro level would be insolation, its economics and the incentives awarded for the installation of solar in that particular state.

Key Drivers for Solar in Telecom:

Insolation:

A quick look at the solar irradiation map of India shows that the southern states of Andhra Pradesh, Karnataka, Tamil Nadu; states in north western India like Gujarat, Madhya Pradesh and Rajasthan; and parts of Maharashtra and J & K have the best solar radiation in the country. These regions receive solar irradiation between 5-7 kWh per square meter per year. Therefore, these areas would make best destinations for solar systems yielding anywhere between 3.5 - 4 units per kW per day on an average.

In comparison, other parts of the country don't receive such a high amount of solar radiation but are fairly well-endowed when compared to nations belonging to the EU.

This constraint might be addressed within few years. MNRE along with C-WET are working to increase irradiance data by developing a network of 51 automatic solar resource monitoring stations around the country[46] and are also creating a detailed solar atlas.

Solar radiation centre should also be operational shortly. MNRE is planning to publish the raw data from such centers.

Subsidy and Incentives:

The Ministry of New and Renewable Energy [MNRE] currently provides capital subsidy of 30

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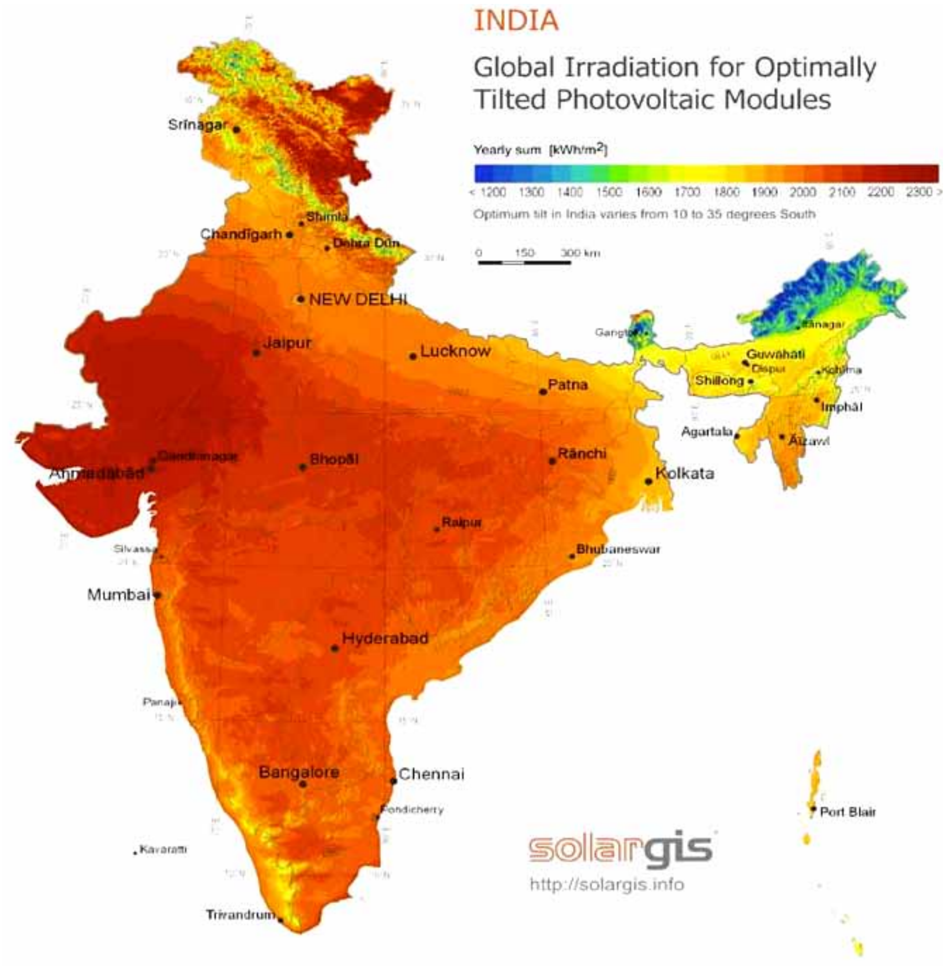
[44]http://www.solar-apps.com/Revised-Capital-Subsidy-and-Benchmark-cost-of-the-SPV-system.pdf
[45]GTM Research and BRIDGE TO INDIA
[46]http://articles.economictimes.indiatimes.com/2012-01-30/news/31005560_1_national-solar-mission-solar-power-project-developers

per cent at INR 81 per Wp[47] (with battery back-up) and soft loans at the interest rate of 5 per cent are being provided across the country.

Additionally, a capital subsidy of 90 per cent is made available for installation of off-grid solar systems for special category states of North Eastern India, Sikkim, J&K, Himachal Pradesh and Uttarakhand.

Solar Irradiation Map Of India



2.10.1.5 Challenges

Solar has few constraints due to which certain site specific conditions have to be taken into consideration before embarking on an economic feasibility analysis.

Space

A 1 kW solar system would require approximately 7-8 sq. m of area. Space is a major challenge in urban areas, however, in suburban and rural areas land is available and solar would be the ideal solution. The PV industry should be more innovative with the design of the PV systems which could be customized according to the available space.

Shading

The solar system would have to be set up in a shade-free zone to ensure the ideal output. Ideally, the proposed space available must be 10 m from the centre of the tower towards the south so that the panels can be placed facing this direction.

[47]http://www.solar-apps.com/Revised-Capital-Subsidy-and-Benchmark-cost-of-the-SPV-system.pdf

Terrain and Slope

Solar requires either a flat terrain or a slope towards the south, ideally between 10 and 35 degrees, with some leeway to the Southeast or Southwest, depending on the location of the tower. The systems can be accordingly designed so as to maximise its output.

Intermittency

Make hay while the sun shines. This adage is literally true for addressing this challenge. The quality of sunshine has a direct impact on the output.

Although India receives over 300 days of sunshine, which is about 5,000 trillion kWh per year or about 600 TW; most parts of the country are overcast with clouds each year.

Even brief cloudy periods can distort the solar output and makes it inconsistent. This is why solar systems go hand-in-hand with batteries. Batteries stabilize the solar output. Any shortage of power from the solar unit can be compensated by batteries for a stable output. Most autonomous systems could be designed with 72 hours standby time, which means that enough energy could be stored to power the BTS loads for 3 days continuously without any solar irradiation. This is one of the advantages of having an integrated solar system. This also requires proper sizing of the solar panels based on the irradiation of the area at which the tower is located.

Since telecom tower systems require constant power supply, battery storage has to be optimised according to site irradiation history in that location. On a safer side, any system should have a minimum of 24-30 hours which can go up to 72 hours as explained before.

2.10.1.6 The Business Case for Solar System

With increased competition and reduced ARPUs, operators have to shift their focus towards cost reduction to ensure profitability. They need a technology that is tested, proven, and is flexible to be used in hybrid models. Solar surely is the right option to explore for the telecom operators.

Over the years solar modules prices have been dropping drastically. As per market analysts Bloomberg New Energy Finance (BNEF), the price of solar panels fell by almost 50 per cent in 2011[48]. They are now just one-quarter of what they were in 2008.

Currently the prices for a watt of PV module ranges between $ 1 – $ 2. This makes buying a solar panel more expensive than buying a diesel generator but over the long run it will get cheaper than diesel. Besides the longevity of a panel is usually 25 years in comparison to the longevity of a diesel generator which is approximately 2 years.

The cost of producing a unit of electricity from solar is about INR 10 – INR 11 per kWh. This is higher than a kilowatt-hour of grid electricity (INR 4 to INR 5) but competitive with a kilowatt from diesel gen-sets which is between INR 22 - 27 per kWh. This shows that solar definitely has an edge over diesel.

In order to run a telecom tower solely on a PV system with battery backup, the generating capacity of the PV system has to be at least nine times higher to match the average load of the telecom equipment. For a tower with a load of 3 kilowatts, a PV system with 25 kilowatts-peak has to be installed.

Battery bank:

The additional battery cost is an important part of the PV system. The average cycle life of existing battery used in the telecom sector is less than 3 years in standby mode and less than 2 years in cycle mode. This needs to be monitored carefully in order to optimize the charge-discharge cycle and level of discharge. Overall the battery system needs to be replaced thrice during the lifetime of a solar system (25 years).

Battery banks require additional space. Since space is a limiting factor in telecom systems

[48]https://www.bnef.com/

it requires innovative design and architecture. Ideally, battery banks should be located in places where climate can be controlled, but it is also important to have good ventilation. PV panel sheds are good locations for battery banks but these sheds should have some form of temperature control system for better functioning.

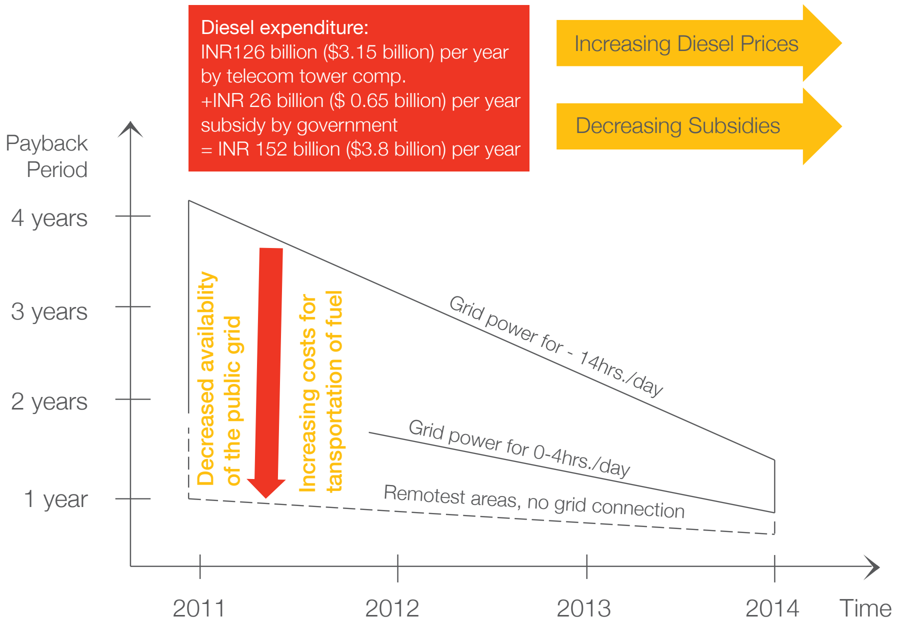
2.10.1.7 Policy incentive and rate of return

According to MNRE there are about 250,000 telecom towers that can employ PV systems. The potential for total installed PV capacity is approximately 6.2 gigawatts(GW).

The payback period for PV systems is estimated to be two to four years in most cases. According to GTM research the payback period will reduce to one year by 2014..

Figure 16: Forecast of Payback Period of PV Systems for Telecom Towers

Source: GTM Research / Bridge to India



Currently as per MNRE guidelines the Central Finance Assistance (CFA) for any off-grid and decentralised solar application would be 30 per cent of the project cost, limited to INR 81 per Wp for PV systems with battery back-up support and INR 57/- for systems without battery back-up support. The pattern of support from MNRE could also include a soft loan at 5 per cent p.a..

There is also a Central Finance Assistance (CFA) of 90 per cent on the initial cost of deployment for solar charging stations with a benchmark cost of 1.5 lakh, which amounts to INR. 1.35 lakh per station. Such options should be explored in solarisation of telecom tower too.

Nevertheless, the ministry has kept a separate provision for innovative applications of solar systems whereby the pilot and demonstration projects can avail a Central Finance Assistance (CFA) up to 100 per cent.

All things considered the case for solar is extremely strong offering returns on investment between 15-50 per cent.

2.10.2 Biomass

Biomass power is the one of the oldest sources of energy. But traditionally, it has always been used as a source of heat energy rather than electricity. In India, energy from biomass contributes to more than 27 per cent of the country's energy consumption. This is due to the fact that biomass is easily available in rural areas and is used in a big way in these regions. However, as a source of electricity, biomass is just starting to pick up pace in India. There is only 2650 MW of installed capacity when we are talking about biomass for electricity.

2.10.2.1 From the telecom perspective

Since diesel is primarily used to power telecom towers in rural areas, where biomass is more prevalent than in urban locations, it makes a lot of sense to consider biomass as an alternative source of electricity.

2.10.2.2 Key Drivers

Location:

A biomass gasifier can be set up anywhere as long as feedstock is available. This factor strengthens the case for biomass with respect to telecom sites since the towers which have no connectivity to the grid are often in rural and backward areas.

Agricultural Economy:

Since India is predominantly an agriculture driven economy, biomass has a lot of potential as the biggest hurdle of feedstock and the supply chain is missing. The future potential of power generation from biomass in India and an estimate (capacity of power) of the surplus agro-biomass available in various states are given below.

Future Potential of Power Generation from Biomass in India

Biomass Type	Realistic			Optimistic			Pessimistic		
	10-13	14-20	Beyond 2020	10-13	14-20	Beyond 2020	10-13	14-20	Beyond 2020
Agro potential	19295	20687	21743	21680	30506	38934	18172	16937	16107

Estimate 2 - Estimate Based on Total Amount of Surplus Agro Biomass Available in Various States

State	Area (KHa)	Crop Productivity (million T/ yr)	Biomass Generation (million T/ yr)	Biomass Surplus (million T/ yr)	Power (Mw)
Andhra Pradesh	2,540.20	3.23	8.30	1.17	150.20
Assam	2,633.10	6.08	6.90	1.40	165.50
Bihar	5,833.10	13.82	20.44	4.29	530.30
Chattishgarh	3,815.50	6.14	10.12	1.91	220.90
Goa	156.30	0.55	0.83	0.13	15.60
Gujarat	6,512.90	20.63	24.16	7.51	1,014.10
Haryana	4,890.20	13.52	26.16	9.80	1,261.00
Himachal Pradesh	710.30	1.33	2.67	0.99	128.00
Jammu	368.70	0.65	1.20	0.24	31.80
Jarkhand	1,299.80	1.51	2.19	0.57	66.80

Karnataka	7,277.30	38.64	23.77	6.40	843.40
Kerala	2,041.70	9.75	9.42	5.70	762.30
Madhya Pradesh	9,937.00	14.17	26.50	8.03	1,065.40
Maharashtra	15,278.00	51.34	36.80	11.80	1,585.00
Manipur	72.60	0.16	0.32	0.03	4.10
Meghalaya	0.80	0.01	0.04	0.01	1.10
Nagaland	27.10	0.09	0.15	0.03	3.10
Orissa	2,436.60	3.63	5.35	1.16	147.30
Punjab	6,693.50	27.81	46.34	21.27	2,674.60
Rajasthan	12,537.50	93.65	204.89	35.53	4,595.00
Tamil Nadu	2,454.00	24.54	15.98	6.66	863.70
U.P	12,628.20	46.80	50.42	11.73	1,477.90
Uttaranchal	66.40	0.14	0.16	0.05	6.60
West Bengal	5,575.60	21.06	23.32	2.96	368.30
	105,786.4	399.25	546.41	139.35	17,982.0

High Utilization Factor:

Biomass gasification units, unlike solar, have high capacity utilization factors of up to 75-80. It indicates that full potential of feedstock is extracted.

Low Cost Resource:

In case of feedstock availability, the costs of production are extremely competitive, sometimes even comparable to grid prices.

2.10.2.3 Challenges

Supply Chain Issues:

Biomass gasification units, unlike solar, have high capacity utilization factors of up to 75-80. It indicates that full potential of feedstock is extracted.

Even though India has a lot of biomass surplus generated, feedstock procurement is often a big problem with biomass. Unless long term contracts for the supply of biomass are secured, there could be huge problems with availability and production of power. Failure to secure biomass could drastically affect the revenues from the telecom site due to unavailability of power.

Gasifier Availability:

The lowest capacity biomass gasifiers have typically been around 20 kW whereas the power requirement of telecom towers usually does not cross 10 kW. Because biomass gasifiers have a high capacity utilization factor of about 75-80 per cent, a 1 kW unit produces about 18 kWh of electricity per day.

This translates to about 200 kWh per day for a 20 kW gasifier which, like we mentioned, are usually the smallest capacities available, although husk power have come up with a 12 kW solution. But even this generates about 216 kWh. Even if we consider a 6 kW telecom load, that's 82 kWh of unused power. Usually unused power is not a problem, but in case of desolate areas this might lead to an unnecessary loss of electricity.

Feedstock price and Escalation:

The economics of biomass power generation are extremely sensitive to the price of feedstock. Prices of agricultural waste have been on the rise due to increased demand, as more biomass power generation plants come up.

Biomass is a cheaper option compared to the current costs of electricity production from diesel. Its cost seldom breaches the INR 12 mark.

2.10.2.4 Business Case for Biomass

Biomass's available potential (18 GW) for production of power makes it an attractive option in the telecom sector in India. It can be used anywhere as long as a supply chain for the feedstock is secured.

The only bottleneck, or perhaps a boon, seems to be the scale of the gasifier that needs to be procured. As mentioned earlier, the lowest capacity of gasifiers available in the market are of 20 kW. This frees up additional power for other uses like rural electrification if the tower in question is near a village, which is quite likely. But this would further entail construction of mini-grids. Construction of mini-grids for capacities less than 60 kW does not require high voltage lines.

Handsets provided to the rural population through the utilization of USO funds and supply of electricity to charge these handsets at a reasonable price would serve more than a single purpose:

1. It ensures that there is no wastage of produced electricity, which is important as telecom loads are hardly above 10 kW anywhere.
2. It opens up another revenue stream for operators or energy service companies, if they are employed as power managers for telecom operators.
3. Supplying electricity to backward areas offers an avenue for operators to fulfil their Corporate Social Responsibilities.
4. Biomass systems are offered a 90 per cent subsidy for rural electrification. It brings down the payback period to less than a few months, and increases the rates of return. Not only does it ensure energy security for the telecom towers but also improves the rural population's standard of living.

Hence it can be said that biomass is a viable source of renewable energy. A cluster of telecom towers in the same area would be ideal.

The problem of generating excess electricity can be solved through rural electrification. It also offers a different source of revenue for the telecom companies and would be a phenomenal game changer for the society.

2.10.3 Fuel Cells

Fuel cells are one of the cleanest electricity sources making use of hydrogen, which has one of the highest energy density per unit mass. The idea of using hydrogen to produce electricity through fuel cells is by not new. Fuel cells have been around since their discovery in 1840 but have struggled to overcome issues with respect to hydrogen production and logistics.

Zero-emissions combined with quiet operation make fuel cells highly suitable for indoor, outdoor, urban or rural applications. And because they can be refurbished at the end of their useful lives, they generate low disposal and recycling costs in comparison to valve regulated lead acid batteries.

2.10.3.1 From the telecom perspective

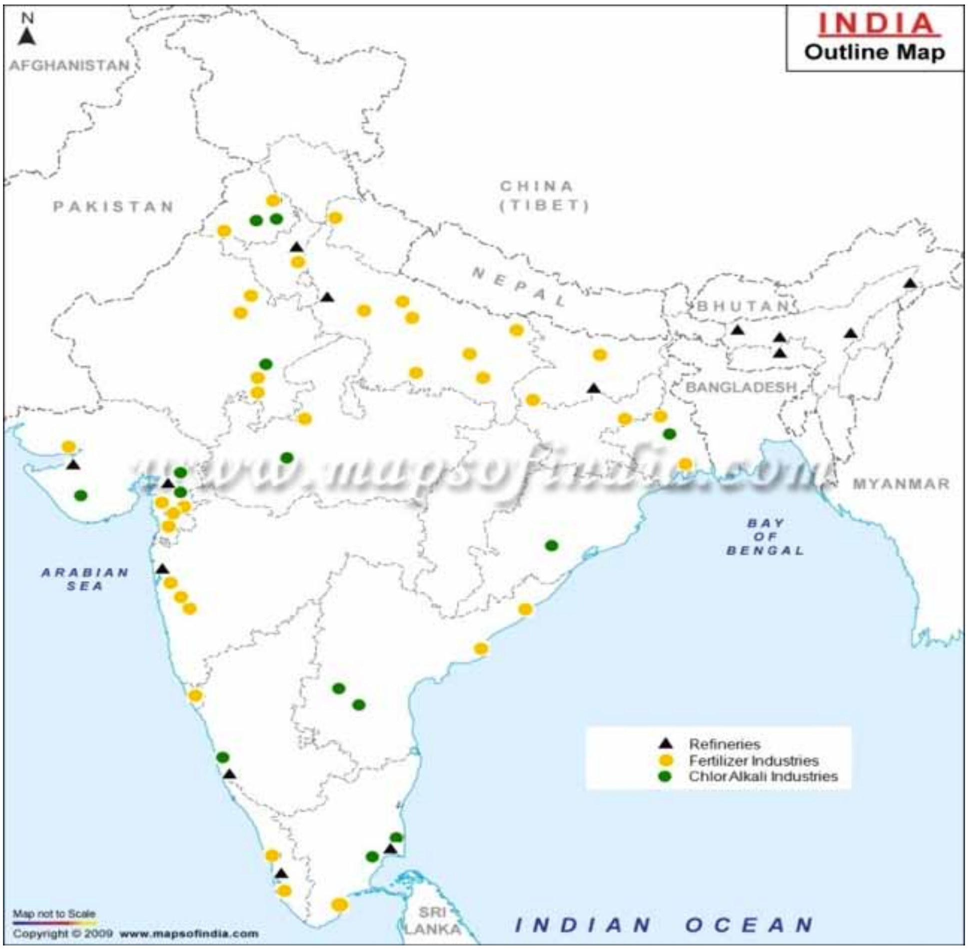
Being one of the cleanest sources of energy, hydrogen fuel cells certainly qualify as a clean technology. Fuel cell solutions offer numerous advantages over diesel generators for telecom backup needs. They provide extended runtime together with reliability at an attractive lifecycle cost.

2.10.3.2 Key Drivers

Location & Availability of Hydrogen:

The biggest driver for hydrogen fuel cell adoption is the location of the telecom tower or any prospective fuel cell application site. Hydrogen is the most prevalent chemical element but is hardly found in isolation. The most popular method of hydrogen production is reform of natural gas. Hydrogen is produced as a by-product in chloralkali plant; biomass plant; refineries; captive plants for fertilizer, soap, glass plants and sugar industries. Reformed hydrogen is sourced from hydro-carbon fuel like natural gas, LPG and methanol. This is how most of the hydrogen is produced today. Location of these plants nearby drives the case for implementation of fuel cells.

There are numerous hydrogen sources available to cater to the needs of telecom towers in semi-urban and rural areas. The map below shows the possible source of hydrogen in India:



Scalability:

Backup power run time is directly proportional to the amount of fuel available for a fuel cell system. So the required backup time can be provisioned by ensuring adequate on-site fuel storage. The fuel cell system occupies the same amount of space within existing enclosures. It is limited by on-site fuel storage capacity only.

Lifecycle Cost Savings:

Fuel Cell systems offer lifecycle cost savings to backup power distributed telecom nodes, particularly at sites requiring relatively low power (<10 kW) over a long duration (>8 hours). Fuel cell-based backup power systems are designed to operate for approximately fifteen years, while diesel generator may need replacement after every three to five years. Additionally fuel cell solutions require only minimal annual maintenance compared to quarterly site visits to service diesel generators.


RenE
OutD

Fuel Cell Systems, Ballard
© Karan Vaid / Greenpeace

Durability and Reliability:

Fuel Cell solutions are reliable with minimal servicing requirements (annual air-filter change) and is minimally compromised by operation at extreme temperatures.

Unit cost of Electricity:

Usually the cost of unit production of electricity is between INR 17 – 25. It excludes maintenance and initial capital expenses.

Cost of I kg hydrogen varies from INR 120 - 150. The actual cost of transportation that depends upon the distance and location of the site is around INR 250 – 350. This quantity of hydrogen is enough to produce 15 kWh of clean power.

If hydrogen is available nearby, fuel cells make an excellent choice for reliable power. At this price level, savings in operational expenditure are high enough to warrant the investment for the energy security that the fuel cell offers.

Hydrogen Supply Chain:

Hydrogen, as said before, is the most prevalent element on the earth but is never found in isolation. Having high energy density, it has been identified as a potential replacement for conventional transport fuels and an energy carrier.

The production of hydrogen has always been an expensive process but hydrogen is released as a by-product in the production of caustic soda; biomass; refineries; captive plants for fertilizer, soap, glass plants and sugar industries. Reformed hydrogen is sourced from hydrocarbon fuels like natural gas, LPG, and methanol.

However, caustic soda is mostly used to produce it. The production of one tonne of caustic soda generates 28 kg of hydrogen. India produces 5.5 million tonnes of alkali which contains 70 per cent is caustic soda. This translates to an electricity production capacity of about 1.3 billion units from the hydrogen generated.

Typically the hydrogen generated in caustic soda plants is used for captive consumption. They need to be made available in a proper supply chain mechanism to use them for power production in the telecom sector. A secure supply of hydrogen is very crucial to determining the success of a fuel cell installation at a telecom site.

Hydrogen Logistics:

50 per cent of the cost of fuel cell comes from storage and transportation. Even if hydrogen is easily available, its storage and transportation pose major hurdles. Hydrogen needs to be stored under a minimum pressure of 150 bars under normal standard in India. However there is possibility that this standard might change in future to 300 bar as per the international standards. In the future as market matures and more players come in, the cost might go down. We have seen this happen in the case of LPG and CNG in the past.

Lifetime of components:

The fuel cell stack, which is the most important component of the system, has longevity of about 8000 hours. If we assume that a site needs a backup for, let's say, 8 hours a day, means that the stack's life is of minimum three years. After which the stack has to be refurbished. The cost of fuel cell stack represents between 20-30 per cent of the system's capital cost and is the only maintenance cost incurred. In comparison diesel generator sets require maintenance after 500 hours and its comprehensive annual maintenance cost is INR 18 / hour.

This means that in a 20 year time period the cells have to be replaced six or seven times. Hence the lifecycle cost of producing electricity using a hydrogen fuel cell is INR 35.

© Karan Vaid / Greenpeace

2.10.3.3 Business Case for fuel cells

Fuel cells offer a beautiful solution to the problem of clean energy production owing to the unreasonably high electricity production costs in backward and rural areas.

Although chloralkali plants generate enough hydrogen to provide close to 1.3 billion units of electricity, they are concentrated in pockets of different parts of the country. Telecom sites present in these pockets should be most conducive areas for installing fuel cell systems.

The operational and maintenance cost is between INR 17-25. Besides, there is a minimum recurring maintenance cost after every 8000 hours for the refurbishment of stake every 3 years. In actual terms this is roughly between 20-25 per cent of the total cost of installation. It is possible that with the burgeoning of hydrogen market, the cost could come down over the course of 3 to 4 years.

This would have an excellent rate of return in areas where the backup hours are 10 hours or less or where the cost of a unit of diesel is higher than INR 50.

Fuel cell's price is poised to catch up with solar and biomass due to research and development in production and efficient storage of hydrogen. Thus it can be a good alternative to diesel.

2.10.4 Small wind & Solar-Wind Hybrids

India is fifth on the list of countries with the highest installed wind capacity. With current installation capacities of about 18 GW and annual installation in 2011 at 3 GW, there is no doubt that it is the most prevalent renewable energy source in India. Small-wind has been experiencing significant growth globally over the last 2-3 years.

2.10.4.1 From Telecoms Perspective

Small wind in itself has some constraints and has been unsuccessful in the past but a hybrid of small-wind and solar systems is a good alternative green power source for telecom towers. With current innovations at design level done by few vendors, the future of small wind is definitely promising.

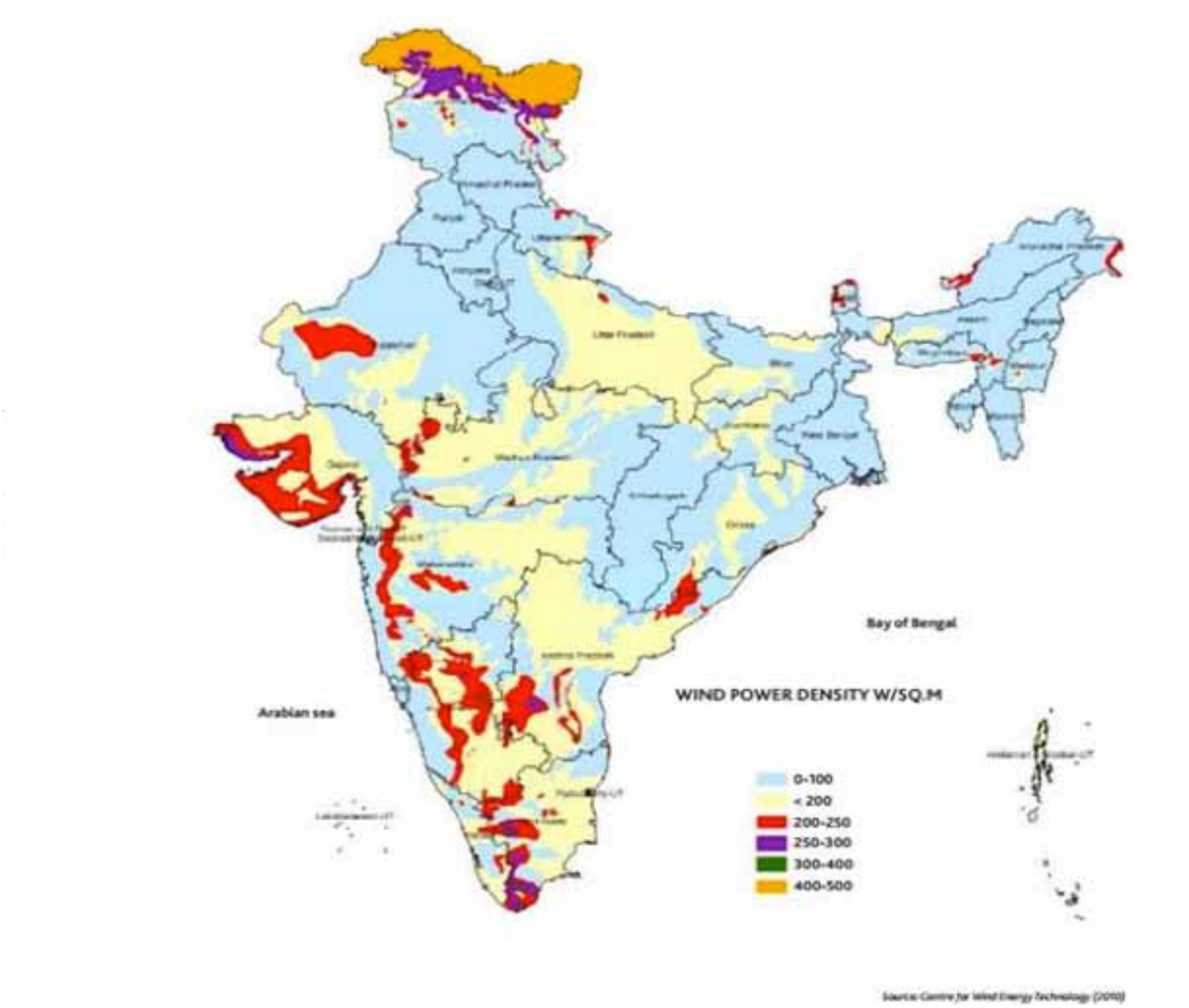
2.10.4.2 Key Drivers

Wind Power Densities:

Pockets of India are rich in wind resources. According to the Centre of Wind Technology's estimates states of Gujarat, Rajasthan, Tamil Nadu, Maharashtra and Karnataka are hotbeds of wind in India (see the figure below). Tamil Nadu has more than 40 per cent of the installed wind capacity in India.

Wind Power Density Map Of India

Sources: Centre for wind energy technology (C-WET)



Complementary Sources of power:

Wind and solar are considered to be a good complementary pair of alternative power sources. It is windy in rainy and winter seasons, which coincides with low solar energy during that period. This gives the hybrid system a competitive advantage over pure wind systems.

2.10.4.3 Challenges

Construction & Installation:

Installation of wind turbines calls for structures of 50 meter especially with small wind, since its height is very important to the optimum generation of electricity. There are two options to achieve this: either affix the turbine on the apex of the tower or construct a separate tower for the wind turbine. The first option limits scalability and would affect the transmitter performance if the installation induces vibrations in the tower. Therefore, structural analysis would need to be performed before installation. However, recent innovation in design happening around the world could enable turbines with low weight, minimal loading and even great efficiency. Some of these innovation as claimed by Southwest Wind Power even could work at height of 10 – 20 meter with an average wind speed of 4.0 m/s[49].

The second option would involve high capital costs for the construction of a tower which could affect project profitability, viability and increase the payback period.

Scalability

Scalability, as we mentioned earlier, is a convenience factor that could influence the decisions of operators or tower companies when it comes to technologies like small wind. When affixed atop a tower after structural analysis has been performed, the scalability of the wind system might face some problem. However, with claimed innovation as mentioned before, this factor might get resolved over time.

Also, If a shade-free space is available in the south-facing direction this problem could be mitigated with the use of solar-wind hybrids.

Intermittency

Although the inclusion of solar to the small wind system greatly reduces intermittency, one can never be sure of the availability of power. Therefore the sizing of the battery system plays the most crucial role like that in the solar power.

2.10.4.4 Business Case for small wind and wind hybrid

1 kW of small wind produces about 3 units on an average day where the wind speeds are in the order of 5 m/s or so. Economically usage of small wind is much favorable and profitable at installations in the those geographic region where the wind speeds are extremely high. In addition, wind power decreases non-linearly as the swept area of the turbines decreases. This is unlike effectiveness of large turbines.

The business case for using wind significantly increases with the introduction of a solar unit. Although the capital costs might be higher than traditional independent wind or solar systems, the overall reliability of the system increases.

Mostly, wind-solar hybrids are more profitable in select locations like the coastal areas of Rajasthan & Gujarat and certain parts of Karnataka, Tamil Nadu and Maharashtra. The levelized cost of electricity generation would for INR 7-8/kWh making it a good choice to replace diesel in the areas where wind supply is over 5 m/s.

Major favorable point for renewables:

- Higher operational expenditure savings
- Extreme ease of operations.
- Financial assistance in the form of incentives

[49]http://www.windenergy.com/markets/telecommunication

PART III

THE ROAD AHEAD

THE ROAD AHEAD

3.1 Introduction

It's clear that the Indian telecom industry is in an expansion mode through the next decade. TRAI's "Approach to Green Telecom" paper was written on account of this evolving scenario. The TRAI exercise was to chart a sustainable growth path for the telecom industry heeding both energy consumption and carbon emission factors.

In this chapter we shall discuss a couple of plausible scenarios for the sector's future. We shall see the effects of these scenarios on carbon emission and the sustainability of the telecom industry by 2020.

Telecommunication in India needs to sustain high growth rates, address energy scarcity issues for rural penetration and adapt a road map for low carbon growth. With this in the background we now look at the two plausible scenarios.

"Telecommunication in India needs to sustain high growth rates, address energy scarcity issues for rural penetration and adapt a road map for low carbon growth."

The first scenario explores present approach, which are measures improvised on the TRAI's directive. In this we look at the future of the telecom sector and where it could be by 2020 in terms of its energy demand, carbon emission and operational cost.

The second scenario explores an alternative approach and the possibility of a carbon-free and a sustainable telecom industry by 2020. This approach envisages India as a historical champion of green energy.

We also look at the investment potential and the market conditions as an extension of our second thesis of a plausible carbon-free telecom sector.

3.2 The present approach

3.2.1 Unravelling the TRAI directive[50]

The TRAI directive issued on fourth January, 2012, was accepted by the Department of Telecom under Ministry of Communication and Information Technology. It had the following mandates:

- At least 50 per cent of all rural towers and 20 per cent of the urban towers are to be powered by hybrid power (Renewable Energy Technologies (RET) + Grid power) by 2015. Further 75 per cent of rural towers and 33 per cent of urban towers are to be powered by hybrid power by 2020.
- All telecom products, equipment and services in the telecom network should be certified "Green Passport [GP]" by the year 2015. Telecommunication Engineering Centre will certify telecom products, equipment and services on the basis of ECR ratings.

[50]Refer Annexure for assumptions

- All service providers should declare to TRAI, the carbon footprint of their network operations. The declaration of the carbon footprints should be done twice a year.

- Service providers should adopt a Voluntary Code of Practice encompassing energy efficient network planning, infra-sharing, deployment of energy efficient technologies and adoption of renewable energy technology (RET) to reduce carbon footprints.

- Service providers should evolve a 'Carbon Credit Policy' in line with carbon credit norms with the ultimate objective of achieving a maximum of 50% over the carbon footprint levels of the base year (2011) in rural areas and a maximum of 66% over the carbon footprint levels of the base year in urban areas by the year 2020.

- Service providers should aim at carbon emission reduction targets for mobile networks at 5 per cent by the year 2012-2013, 8 per cent by the year 2014-2015, 12 per cent by the year 2016-2017 and 17 per cent by the year 2018-2019.

3.2.2 Analysis

These directives take into account the network planning, infrastructure sharing and energy efficiency measures put forth in TRAI's "Approach to Green Telecom" paper after consultation with industry stakeholders.

The carbon footprint of the network portion of the telecom industry stands close to about 16 million tonnes[51] annually. Almost 50-60 per cent of this can be attributed to the use of diesel in the industry.

The tower industry in 2011-2012 consumed about 15 billion units, which includes both grid/EB and DG sets. This was projected to move to 26 billion units. However due to fewer new towers constructed than the forecasted number, the total electricity requirement should go down by end 2012[52].

2011 – 2012 [Diesel/DG]

Consumption	Carbon Emission
3.2 billion litres	8.4 million tonnes

Each litre of diesel emits about 2.63 kg of carbon-di-oxide

In Telecom Context:

Every litre of diesel gives about 2.5 units (kWh) of electricity, which means that about 8 billion units of electricity is sourced from diesel[53]. In urban areas the load is higher, DGs are loaded optimally and give almost 3.4-3.5 units a litre. DGs consume more fuel in rural areas than is needed to produce one unit due to inefficient loading. As a result, they produce only about 1.8-2 units a litre. An average of 2.5 units is assumed as the weighted average output per litre of diesel.

2011 – 2012 [Grid/EB]

Consumption	Carbon Emission
10.1 billion kWh	8.5 million tonnes

India's mix is such that 0.84 kg of carbon di-oxide is emitted for every unit of electricity consumed[54].

In Telecom Context:

Almost 50 - 55 per cent of its power comes from the present grid /EB .However, an allowance of 3-4 per cent can be made to account for the renewable energy source generation.

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[51]TRAI calculated 16 million tonnes on account of telecom towers in its "Approach to Green Telecom paper"
[52]Refer annexture
[53]EAI Analysis
[54]Approach to Green Telecom- TRAI

3.2.3 Methodology

TRAI and industry stakeholders discussed measures that could be implemented to lower carbon emissions. This discussion helped shape the TRAI directive issued earlier this year. The measures suggested in this paper use a series of assumptions from the directive. This is an attempt to project the telecom energy and its corresponding carbon emission scenario in 2020, presupposing that the TRAI mandates are strictly enforced and followed.

3.2.4 The Path

Expansion is expected to be carried out primarily in the rural areas in the coming years. Judicious use of low capacity, high coverage systems and careful network planning to optimize the tenancy ratios of existing towers are some of the approaches recommended by TRAI.

With the use of new, improved products from innovative OEMs, TRAI expects reduction in BTS power demand to as low as 500W by 2020.

This demands an annual efficiency improvement of 3.7 per cent. The power required for the same configuration dropped by almost 41.6 per cent in the last three years. Hence it would be appropriate to assume an annual energy efficiency improvement of 7 per cent for the projection of carbon emissions.

Small scale adoption of passive and active infrastructure sharing and a sound network plan can cause this tower growth rate to drop from gigantic 30 to 60 per cent levels to mid-single digits.

A significant progress has already been made in the BTS cooling demands like compartmentalization of BTSs to reduce the cooling area. This can help lower the average consumption for an average shelter between 700 - 800 Watts[55] by 2020 (free cooling units demand about 250 Watt).

TRAI's mandate to power 50 per cent of rural towers and 20 per cent of urban towers by 2015 would entail repowering close to 34 per cent of existing towers in rural areas and 4 per cent of existing towers in urban areas with greener and cleaner sources of energy. [Since retro-fitting is harder than powering new towers with hybrid sources, the best approach should be to equip new towers with hybrid sources and then retrofit existing towers].

"With the use of new, improved products from innovative OEMs, TRAI expects reduction in BTS power demand to as low as 500W by 2020."

This could be the easiest approach taken under this assumption. It will also ensure that only new towers consume electricity from the grid/EB and renewable energy resources.

Enforcement of such regulation would save more than 540 million litres of diesel on an average annually, and about 3.5 billion litres of diesel cumulatively by 2015.

The operators' saving in revenue expenditure would be a minimum of INR 2430 crores annually[56].

The public exchequer could also make huge annual saving from indirect subsidy on diesel. The estimated amount is close to INR 380 crores[57] annually.

The accumulated savings could be more than INR 15,800 crores, if the rise in operational cost is taken as 5 per annum.

But the biggest gainer from this would be our own environment, as every year an additional 1.4 million tons of carbon emissions[58] would be reduced. For example, 1.4 million tons would be saved in the first year, 2.8 million tons in the second year (1.4 million tons additional) and 4.2 million tons in the third year: total saving of close to 9 million tons.

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[55]Refer Annexure for assumptions
[56]540 million litres*Rs 45/litre
[57]It has been estimated, after analysis, that the government subsidizes diesel by Rs 7/litre on an average.
[58]Each litre of diesel emits about 2.63 kg of carbon di-oxide when burnt

To reach the 75 per cent mark in rural areas by 2020, 70,000 of the existing towers will need to get rid of diesel in rural areas (based on our projection which has been covered earlier in the report). In urban areas a target of 33 per cent can be reached by powering the new towers with a mix of grid and renewable energy.

"Enforcement of such regulation would save more than 540 million litres of diesel on an average annually, and about 3.5 billion litres of diesel cumulatively by 2015."

This will lead to an additional annual reduction of 123 million litres of diesel. The accumulated revenue savings for the operators could reach a staggering amount of INR 8,300 crores over the 5 year time period (2015-2020).

The public exchequer's savings from indirect diesel subsidy could reach to an amount of INR 86 crores annually by 2020.

This translates to an overall total indirect subsidy saving of INR 1300 crores for the public exchequer from the telecom tower industry.

Besides, it would lead to a phenomenal reduction in carbon emissions by 5 million tonnes over a span of 5 years with 2015 as the base year (2015-20). Eliminating 123 million litres of diesel every year would mitigate 322,000 tonnes of carbon emissions additionally every year i.e. 322,000 tonnes in the first year, 645,000 tonnes in the second, close to a million tonnes in the third, 1.3 million tonnes in the fourth and 1.6 million tonnes in the last year.

3.2.5 Shortfalls of the present approach

Even at its best, this scenario entails running of more than 70,000 towers on diesel for about 10 hours on an average in rural areas alone. This would consume close to a billion litres of diesel.

The second phase (2015 – 2020) of implementation in the TRAI directive goes considerably easy on the telecom operators. It requires only a shift of 25 per cent of the towers from diesel usage.

As a matter of fact the rate of shift expected from sites in urban areas is also quite low leaving a lot of room for improvement in the mandated adoption rates.

Capacity Required for the shift:

Total Power Required in Rural with Minimum Energy Efficiency Improvement by 2015	1088 MW

Considering 50% of these towers have to be powered just by grid/EB and renewable energy sources, the capacity of RET required:

By 2015	Power Required
Decentralised Biomass	724 MW
Decentralised Solar	1800 MW
Jawaharlal Nehru National Solar Mission, provision for all decentralised system	1000 MW

By 2020	Required Power
Solar	3400 MW
Bio Mass	1350 MW

The above figures are almost 90% of the JNNSM target including the aspirational target. This shows that there clearly needs to be a renewable energy policy dedicated to the telecom industry to aid its migration to renewable energy sources.

The Telecom Regulatory Authority of India [TRAI] move is definitely one in the right direction. However, implementations would require mammoth additions in terms of renewable energy capacities and all available renewable energy sources need to be utilized to economically optimize this transition.

While the problem of diesel is being mitigated, eventually, the industry will have to move towards a low carbon economy while delivering maximum output.

3.3 The Alternate Approach

A structured approach is needed to achieve large scale reduction in diesel consumption and carbon footprint. This is imperative as the percentage growth of BTS's number will be more than the double of the percentage growth of towers,. The towers will grow at mid-single digit over the next two years.

This will be relevant to the urban areas with increased tenancies and BTS that will be mounted on the existing tower network with excess capacity.

However new towers have to be erected in rural areas for adding more BTS as the expansion would happen in uncovered and small off-grid villages.

BTS deployment in India's telecom sector stands at 6, 80,465 as on September 2011, pointing at a growth of over 20 per cent from September 2010. BTS expansion in FY 2011 was limited to metro and category "A" circles, whereas post FY 2011 telecom service providers moved towards untapped rural markets with electricity crisis and high diesel usage.

The main drivers for the BTS growth would be congestion in urban areas due to 2G subscriber growth and increased data usage. Telephony in India has moved from voice to data leading to rural subscriber growth and planned roll-outs of 3G and 4G services.

As a result the network operating expenses of telecom providers will move higher. This is a critical issue as an increase in diesel prices is imminent. Diesel prices have almost tripled from INR 14 per litre in 2000 to INR 41 per litre in 2011; as on July 2012 it was INR 43 per litre. A further price rise along with diesel deregulation is expected in the future.

"Diesel prices have almost tripled from INR 14 per litre in 2000 to INR 41 per litre in 2011; as on July 2012 it was INR 43 per litre."

A price rise would add to the network operational costs of the telecom operators. But a switch to solar energy could be profitable as the capital expenditure in renewable energy technology has declined.

The below figure shows the annual rise of operational expenditure along with escalated diesel price is 5 per cent. It compares it with the cost of solar, which is cheaper.

An approach that includes optimum utilization of the available renewable energy sources effectively to their fullest potential is the right roadmap towards the transition from diesel to solar power.

3.3.1 A Diesel-free Tower industry[59]

The unsustainability of the current diesel economy in the context of telecom towers was explained earlier in the report. The number of expected towers to be added till 2020 is in the order of 2.4 lakhs[60] as projected in the figure below.

[59]Refer Annexure for assumptions
[60]ICRA Tower Report, April 2012 predicts a 6% annual growth in towers

Figure 17: Projected Tower Growth[61]
Sources: ICRA, EAI Analysis

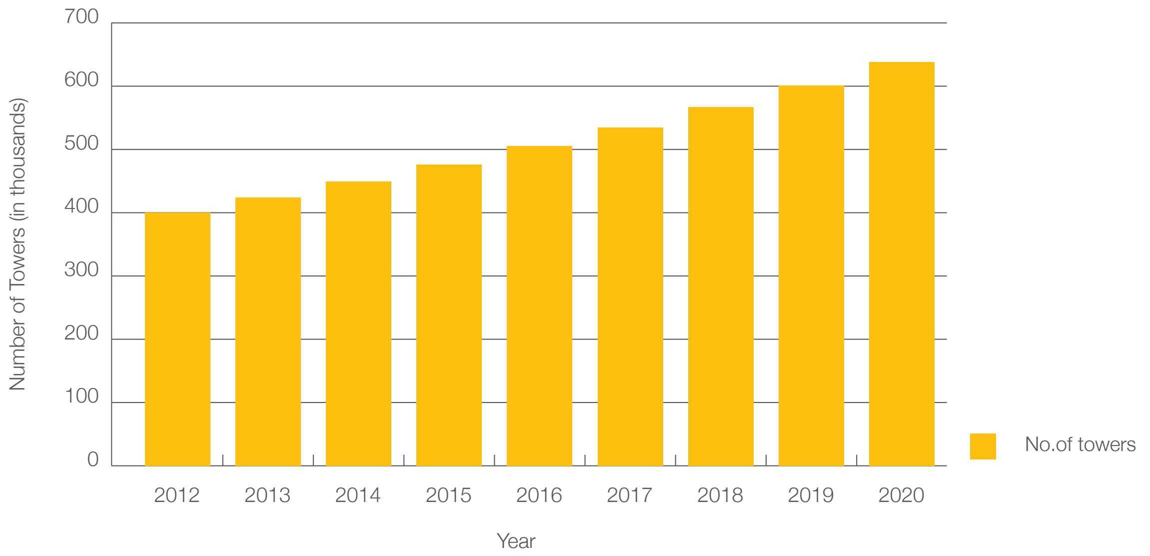
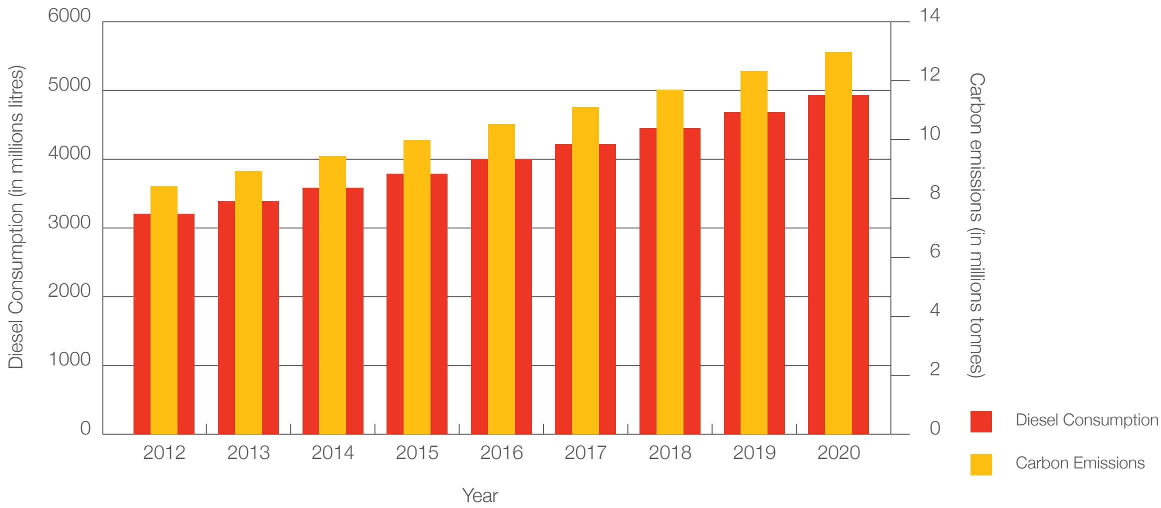


Figure 18[62]: Corresponding Diesel Consumption And Carbon Emission Projections



Figures 17 and 18 show that as the number of towers increase, so would the corresponding diesel consumption. The addition in the number of towers would increase the diesel consumption by the order of 216 million litres[63] and carbon emissions by 500,000 tonnes[64], on an average, annually if business continued as usual.

3.3.2 Methodology

An attempt, at defining this approach, is made in the subsequent section. The proposed approach starts by looking at the tower industry from two angles:

- The new towers that will be added by 2020.
- Retrofitting the towers already in place by 2020.

[61]Sources: ICRA, EAI Analysis
[62]EAI Analysis
[63]ICRA Tower Report, April 2012 predicts a mid-single digit annual growth in towers
[64]EAI Analysis

3.3.2.1 New Towers

A 50 per cent cumulative growth is expected in the number of towers over the next 8 years. A majority of these new towers will be added with more BTS in rural and semi-urban areas as expansion into rural areas will be operators' priority in the coming years.

It is imperative that these new towers be erected in a prudent manner. The idea should be to power them by a hybrid of renewable energy sources and grid power.

The location of new towers is under complete control of the operators and can be judiciously picked to leverage different sources of available power.

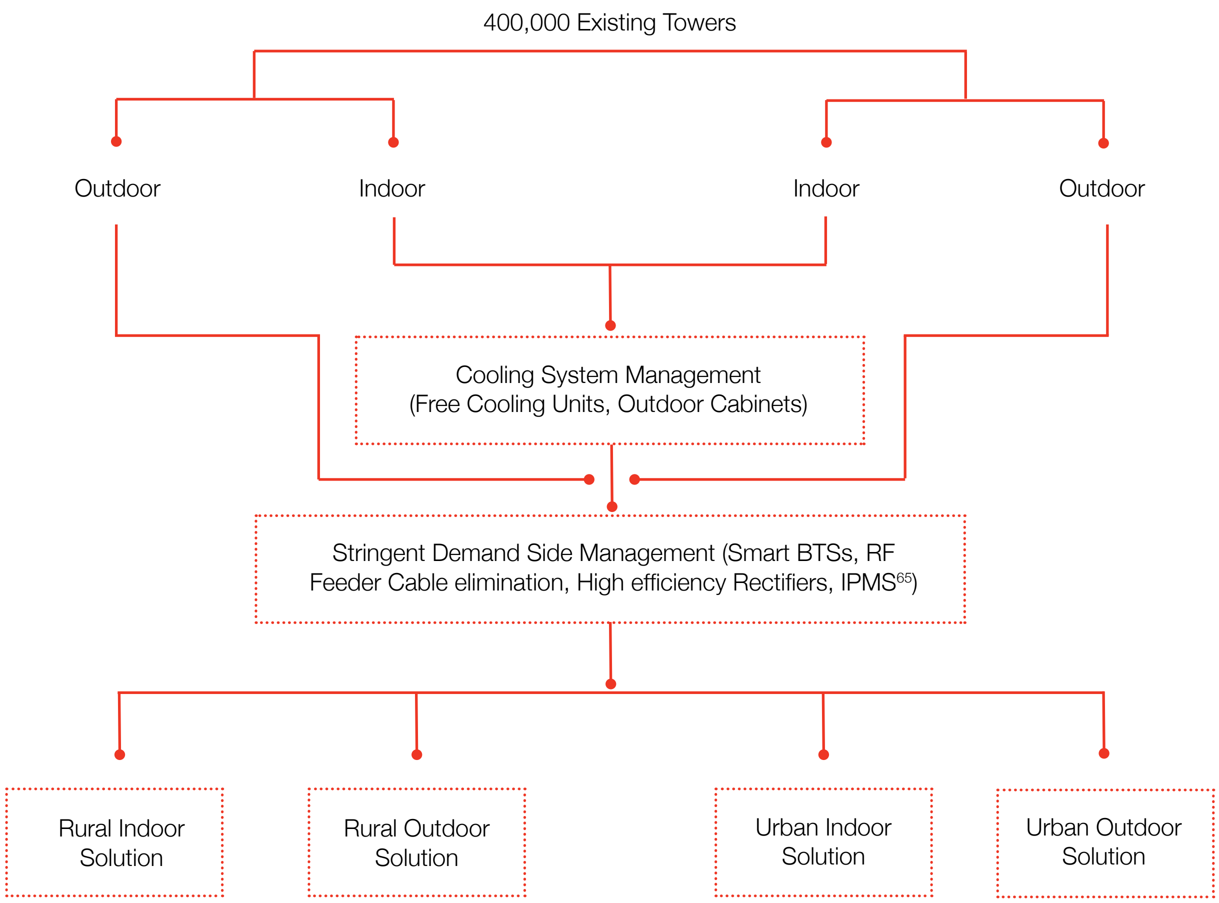
Demand side management and optimum utilisation of available renewable energy sources have to be considered before setting up a tower to ensure optimum sizing and installation of renewable energy sources. They would help bring down the capital costs. Most of the parameters for using available RET's have been discussed before in the report.

"The location of new towers is under complete control of the operators and can be judiciously picked to leverage different sources of available power."

3.3.2.2 Existing Towers

India has a strong web of 4, 00,000 network towers and over 70 per cent of them are located in off-grid, rural and semi-urban locations. In 60 per cent of these towers BTS's are placed in indoor shelters as the old generation equipment cannot function beyond certain temperatures. This is one of the most critical fallout of existing towers that makes them power hungry.

The biggest challenge that the tower industry will face as it expands is this mission-critical power demand, while ensuring low energy consumption and minimal diesel usage.



[65]Integrated power management systems

Rural Outdoor Solutions:

Currently rural outdoor tower sites' biggest expense is caused by per unit (kWh) electricity from diesel. As discussed before these sites lie in rural and extremely backward areas where loads are low, pilferage is rampant and the transport cost of diesel is extremely high.

In such areas, the unit cost of electricity can go up to as high as INR 80-90/kWh. In such a situation any alternative solution becomes viable economically.

Renewable energy options have enough potential to replace ALL or at least 98 per cent of the diesel generator in rural outdoor areas. As towers in these areas are the highest consumers of diesel, this would help operators fulfil the TRAI mandate, cut down their operational costs and improve profitability.

> "Renewable energy options have enough potential to replace ALL or at least 98% of the diesel generator in rural outdoor areas."

Urban Outdoor Solutions:

For urban locations the unit cost of electricity is not very high because the loading efficiencies are better due to multiple BTSs in a single tower. But since the load is higher, there is a fair amount of diesel consumption even if it runs for 2 to 3 hours.

Land and rooftop space is an expensive commodity and a huge constraint in urban areas. For any RET to become an economically viable alternative, it would need a greater innovation in architecture. Batteries are the ideal alternative to diesel generators in urban areas and can help significant reduction in diesel usage. But it is extremely important to monitor the charge-discharge cycles carefully to optimize its performance as discussed before.

Rural Indoor Solutions:

Indoor shelters house old generation BTSs that need to be cooled beyond a certain temperature to function normally. Various new innovative and more efficient methods of cooling as discussed before in the report can significantly reduce the load demand.

Where free cooling is not an option, compartmentalization of BTSs in small outdoor cabinets significantly reduces the area to be cooled and thereby the load.

Demand side management techniques mentioned in the previous section viz. high efficiency rectifiers, integrated power management systems etc., if employed can also lower the overall load of the system.

A hybrid of solar and biomass or even a hybrid of solar and small wind sets along with battery offer clean as well as profitable solutions in these cases.

Urban Indoor Solutions:

Efficient cooling methods proposed in the previous section can be applied to indoor towers in urban areas. Besides, stringent energy efficiency measures that have been proposed previously also hold good for these towers.

Ideally, batteries can be considered in the same vein as mentioned in the previous section. The approach to eliminate diesel from such towers would be similar to urban outdoor solution.

3.3.3 The Path

The first step is to eliminate diesel consumption in rural and semi-urban areas. 70 per cent of India's towers are in these areas.

This constitutes a total of 280,000 towers, out of which around 20 per cent are in areas where the average electricity availability is less than 4 hours.

The path towards elimination of diesel from towers has to start here and eventually it has to move towards the urban regions.

It constitutes 20 per cent of 400,000 and this should be the starting point.

With an ambition to be diesel free by 2020, 12.5 per cent of these towers need to be retrofitted every year like this. This approach would make the entire 100 per cent of the towers diesel-free within 8 years.

This would eliminate an average of **390 million litres**[66] **of diesel** usage every year and an estimated amount of about **3 to 3.2 billion litres** by 2020.

Correspondingly, it would also prevent a carbon emission on an average of 1 million tons every year into the atmosphere.

Cumulatively this approach would allow the telecom tower industry to prevent 37 **million tonnes** of carbon emissions during the course of 8 years if this approach is taken with 2011 as the base year.

Saving subsidies for the public exchequer would be close to INR 273 crores every year.

"For the telecom companies average savings would be INR 10,000 crores every year that adds up to nearly INR 80,000 crores over the 8 year period."

For the telecom companies average savings would be **INR 10,000 crores** every year that adds up to nearly **INR 80,000 crores** over the **8 year** period.

The operational expenditure savings also motivate them to cut their diesel costs and at the same time to fulfil TRAI mandates!

This saved operational expenditure could serve as a means to increase expenditure on research and development and for adoption of new renewable energy technologies.

3.3.3.1 Learning from the Path

Let's assume that a litre of diesel produces about 2.2 to 2.4 units (kWh) of electricity on an average after considering its inefficient load patterns[67]. We find that close to 900 million units of electricity need to be produced from renewable energy sources every year to cater to the electricity gap created by the removal of diesel.

2011 – 2012 [Diesel/DG]

Solar potential capacity addition by 2020 [YoY]	640 MW
Creation of rural Job-years	6400 - 12800

Each megawatt of solar creates about 10 -20 jobs on an average for a year[68].

If this approach is taken it would be game changing for rural societies. Besides connecting the digital divide with an increased mobile phone usage, it would benefit the operators in terms of revenue and fulfil their social responsibilities as big business groups.

This level of reduction would ensure "inclusive sustainable growth" for all stakeholders involved and a phenomenal benefit for all parties.

[66] 3-3.2 billion litres over 8 years will give a figure close to this
[67] EAI estimate
[68] Energy for Economic Growth Energy Vision Update 2012, Industry Agenda Prepared in Partnership with IHS CERA; One job-year equals full-time employment for one year

3.4 Connecting the digital divide using Universal Service Obligation fund

As discussed before the Universal Services Obligation (USO) Fund, maintained by the Department of Telecommunications, promotes connectivity in remote and rural regions. A share of the fund is targeted to promote mobile infrastructure. Providing power to rural digital infrastructure through clean energy to connect the existing digital divide can be a role model that involves all the stakeholders.

Source: USO Fund Scheme I data

The first phase of shaping mobile access was rolled out in 2007. About 7,363 mobile infrastructure sites spread across 500 districts and 27 states to provide mobile services in rural and remote areas without wireless or mobile coverage. Villages or cluster of villages with a population of 2,000 or more were taken into consideration for the installation of towers under this scheme.

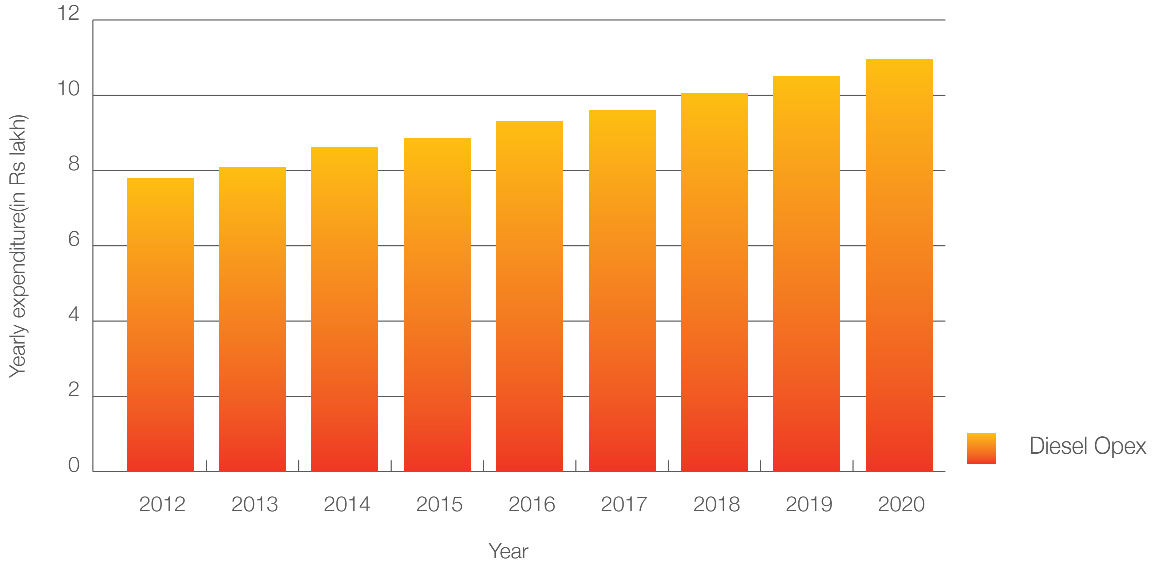
In the second phase, deployment of additional 10,000 plus towers would be supported to enable and strengthen mobile coverage in about 2, 00,000 villages either at the village level or as a cluster of villages with population between 500 and 2,000[69]. The fund adds up to the market potential and investment opportunities and catalyses the approach in these areas.

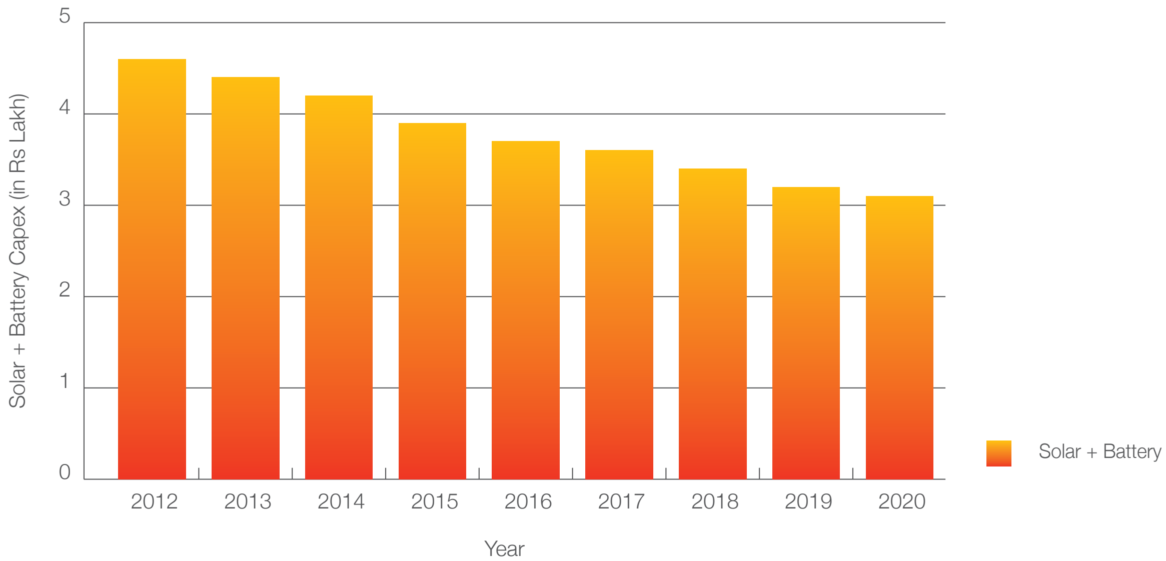
[69]http://www.usof.gov.in/usof-cms/usof_agreement_VIII.html

3.5 Market Potential and Investment Opportunities

Figure 19: Falling Renewable Energy Capex Vs Rising Diesel Opex Over The Next 8 Years[70]

Sources: EAI Analysis





The above figure from a 2 kW telecom tower shows how the operational expenditure will be on the rise, if we assume that the price of diesel escalates by an average of 5 per cent annually. Meanwhile the cost of solar with a battery solution would get cheaper.

If the industry opts for the zero diesel network by 2020 incremental capacity additions of renewable energy are required to cater to the demand of existing towers. The deployment of new and energy efficient equipment both on the cooling and network sides would bring the demand close to 640 MW of solar equivalent renewable energy power to fill the electricity gap after the elimination of diesel.

If 12.5 per cent of this demand is addressed incrementally over the next 8 years until 2020, the electricity demand from existing towers currently met through diesel shall be removed. Further all new towers would have a mix of grid and renewable energy resources to address their electricity requirements.

[70]Sources: EAI Analysis

Let's assume that an average rural and semi-urban tower has to be powered by renewable energy for 8-10 hours. This would require at least 120 solar MW[71] added annually, which entails the installation of an average of 760 MW of solar equivalent renewable energy capacity.

It calls for an investment of INR 8,360 crores[72] per year with the total required investment close to INR 67,000 crores by 2020. In comparison the operational expenses based on diesel would be around INR 80,000 crores.

With renewable energy installations a payback period between 4 and 6 years is not uncommon. But with diesel a payback period between 4 and 6 years would be the upper limit in most rural regions!

If we compare the required investment for renewable energy resources to the accumulated operational savings of INR 80,000 crores in 8 years we get a clear case in favour of renewable energy systems from operational savings alone.

Environmental emission, the imminent price rise, high operations and maintenance costs, and pilferage have taken their toll on the telecom operators' business.

This is why many operators have started to explore alternative energy options to use them as backup power and to decrease their dependence on diesel.

3.6 Encourage Financing

Telecom operators need to build trust and cooperation among stakeholders to bolster investor confidence and to overcome the problem of high interest rates in India. The money is on the table, it's just on the wrong plates.

Enabling finance models need to be formulated with combined efforts of all stakeholders involved, the banking community has to acknowledge the present problem and make provisions for easily available finance. The Government of India could perhaps rework the existing Renewable Purchase Obligations (RPO) to include the telecom towers and make it an obligation for operators to utilize these resources. Through this it should also share additional information on the Payment Security Mechanism, which covers potential defaults on payments.

Telecom operators might also like to look at the developing Renewable Energy Certificate (REC) market as enabling financing model. The Reserve Bank of India and the Finance Ministry could work with Ministry of New and Renewable Energy (MNRE) to support solar energy and other RET investment, and the private sector [telecom + RESCo] could lead by syndicating loans and sharing experiences in India's solar market.

3.7 Financing Routes

There are close to 400,000 towers that require electricity at all times. Eventually, once market forces takes over, various new financing avenues, both from the debt and equity side open up in the form of project funding, private equity investments, multi-lateral financing and venture capital investments.

3.7.1 Multi-lateral financing

In the absence of solid policy support as is in the case of renewable energy for telecom towers, cheap sources of financing always help the development of a market. Multilateral

[71] Refer Annexure for assumptions

[72] We have assumed Rs 11 crores/MW on average because it would be divided between different renewable energy sources and biomass systems cost half as much as solar does.

financing agencies such as the Asian Development Bank and Export-Import bank of the US offer cheap sources of funds for renewable energy projects contingent upon certain criteria.

These institutions have pledged huge sums of money to aid development of rural areas in the developing world. Combining the telecom case with rural electrification might open the doors to these sources of capital for innovative vendors.

3.7.2 Non-recourse Project Financing

The telecom energy market is likely to see participants undertake large contracts to provide electricity to thousands of towers. A new vendor might not have access to the funds required for the installation of renewable energy systems.

This type of financing becomes available to interested financing institutions but it must be mentioned that renewable energy projects are yet to win the favour of project financiers, even for mature megawatt scale projects. The suggested Telecom Entrepreneurship Development Fund of INR 2500 crores in 12th plan could prove handy.

3.7.3 Private Equity and Venture Financing

Innovative business models have the ability to attract risk-takers. Venture capitalists have a higher risk appetite than traditional banks and non-banking financing institutions and do not mind investing in sectors with higher risks.

Interested entrepreneurs can look at venture capitalists as a source of funding since this has been established as a $20 billion industry. VCs have been one of the biggest sources of funds for the clean technology industry.

Private equity players enter the picture once a sound business model has been established and the firm has concrete cash flows. They typically look for companies that need capital for expansion. A telecom vendor who has secured a contract with a tower company for its energy needs, and is strapped for cash could be someone a private equity player would be interested in.

Banks and financial institutions have been sources of funds for the renewable energy industry but most of these funds have been in the form of recourse financing where the collateral includes ALL company assets and not just the project assets. The disadvantage for the investor is that there is larger downside risk as compared to non-recourse funding but the upsides remain unaffected. Besides, the cost of finances is higher than non-recourse funding.

Possible business model: (OPEX)

In the OPEX model operators get green energy without investing in CAPEX. This gave birth to the concept of OPEX based business model. In this scheme a renewable energy service provider invests in CAPEX to deploy clean energy based power sources at the telecom site. The operator is then charged on a monthly basis, either on a kWh usage basis or flat fee basis. According to GSMA, about 2000 stand-alone green power telecom sites have been implemented with the OPEX business model in India[73] currently. The success of such business model depends on strategic partnership between the telecom operator and the RESCo.

[73]http://www.gsma.com/developmentfund/wp-content/uploads/2012/03/gpmprocurementmodelanalysiscapexvopex.pdf

3.8 Rural electrification

Approximately one-fifth of the world population (1.4 billion people), with a vast majority residing in rural regions of South Asia and sub-Saharan Africa, does not have access to electricity. Close to 300 million of this population of the world lies in India.

This lack of access to modern energy facilities has staggering consequences for human health, economic development, political stability, and is a major inhibitor of achieving equitable growth and building greater resilience of poor and vulnerable communities.

An approach to integrate the demand for rural electrification to diesel replacement needs of the telecom tower segment shall create an opportunity to decentralized renewable energy providers. It shall also open up vistas for private enterprise development and private capital participation.

"An approach to integrate the demand for rural electrification to diesel replacement needs of the telecom tower segment shall create an opportunity to decentralized renewable energy providers. It shall also open up vistas for private enterprise development and private capital participation."

This presents an unique opportunity to the telecom industry to not only cut costs but also create positive economic, social, and environmental impact in the communities they serve.

Greenpeace has been working with a community in the state of Bihar to see how a real community could create their own electricity services in a sustainable way.

The core concept for communities was to be able to organise their own electricity supply step by step, build up a local micro-grid that runs on locally available renewable resources.

They facilitate integration of renewable energy and reduce transmission losses as power generation takes place close to the area of demand.

Micro-grids involve additional investment but if demand is established the investment can be recovered quickly based on the set tariffs.

Other entities like banks and hospitals can be involved as stakeholders in rural electrification projects. These institutions are also on the verge of expansion into rural areas where electricity is a major problem.

Surplus electricity in any rural area creates benefits both for the vendor and the institution looking to expand into these areas by opening up different revenue streams.

Setting up micro-grids in rural areas where telecom towers are present decreases the risk of the investment because telecom towers require continuous supply of electricity and serve as an anchor load.

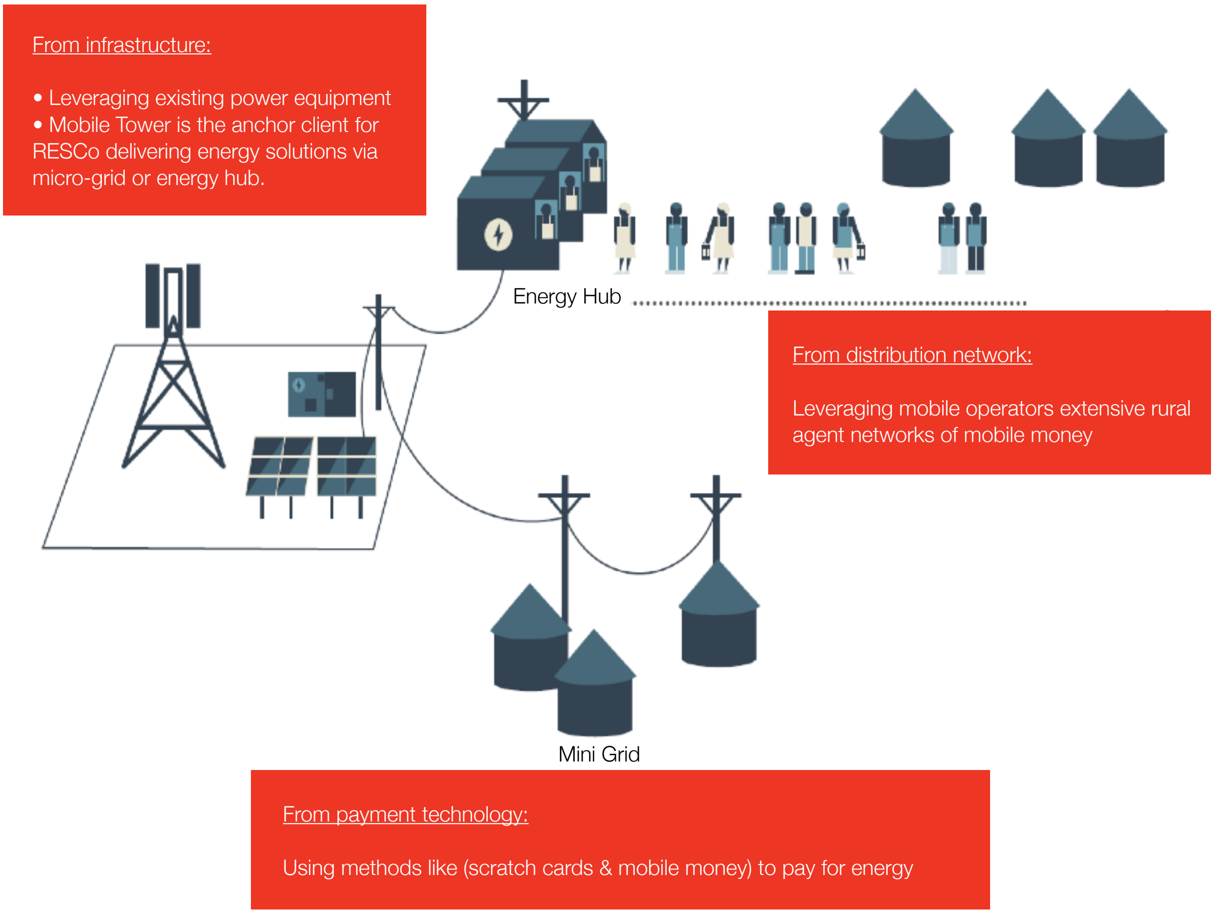
This give rise to a unique business model and opens up opportunities for investment. Following such a business model would ensure the growth of the entire eco-system and improve overall quality of life in rural areas. It's a win-win situation for all.

"Greenpeace has been working with a community in the state of Bihar to see how a real community could create their own electricity services in a sustainable way."

A villager in the rural community using a mobile phone
© Vivek Muthuramalingam / Greenpeace

Aspects of Mobile Towers providing sustainable energy access

Source: GSMA



3.9 Saving a million lives

Apart from providing energy to communities living beyond the grid, green energy could save millions of lives.

At least 2 million people die each year from vaccine preventable diseases. These deaths are not because there is a lack of vaccines and medications in the world, but because there is an inadequate vaccine distribution process due to lack of inadequate energy infrastructure and refrigeration systems.

Besides, inadequate access to clean water results in millions of death. According to the World Health Organization 3 million people die each year from diseases spread by unclean water.

Both these issues are due to severe lack of electrical infrastructure and have a direct relation to high death rates in these regions. According to a study done in 2007, 90 per cent of local health centres in India suffered frequent power failures and only 45 per cent had a back-up generator[74].

The Cold Chain concept/program started by Energy for Health[75] supported by World Health Organisation is an ideal solution to mitigate these issues. It focuses on harnessing an adequate portion of electrical energy from telecom towers to power refrigeration units and water filtration systems.

It is an innovative power solution to global health care and needs for sustainable, clean energy.

[74]http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1802111/pdf/phr122000112a.pdf
[75]http://energizethechain.org/sites/default/files/Energy%20for%20health%20--%20presentation.pdf

3.10 Incentives for mitigation actions

3.10.1 The National Clean Energy Fund (NCEF)

For enabling an incentive mechanism for this transition, the National Clean Energy Fund (NCEF) that was created by the GoI could be explored for such projects. At the present level of cess on coal at INR 0.50 per tonne, the NCEF would have annual accretions to the tune of INR 3000 crores per annum.

The fund is intended to support all kinds of clean technologies, including renewable ones. The detailed implementation plan provides for this (including the involvement of IREDA), which is the principal financial institution functioning under the Ministry. It needs to be noted that the funds are controlled by the Ministry of Finance, GoI and the Ministry will be interfacing extensively with the Ministry of Finance for effective allocation. With the kind of saving the public exchequer will incur from green telecom as detailed earlier in the report. The Department of Telecommunication could possibly look at such support.

3.10.2 Nationally Appropriate Mitigation Actions (NAMA) under UNFCCC

Post-2012 climate regime, NAMA is emerging as a possible way of incentivizing and encouraging developing clean energy infrastructures, especially in developing countries. It is supported and enabled by technology, financing and capacity-building, in a MRV (Measurable, Reportable, and Verifiable) manner, as defined by the Bali Action Plan. It also includes the allocation of the Green Climate Fund which is estimated to be about $100 billion per annum by 2020.

Looking at the amount of emission reduction possible from adoption of clean energy by telecom, it will add in the net global reduction by 2020, and hence it qualifies for NAMA. So, there is huge amount that can be availed.

In the next section, we look at some case studies which involve migration to energy efficient systems and adoption of renewable energy resources.

CASE STUDY I

3.11 VIOM , ALTA Energy, KOLAR (Karnataka)

Introduction

The outdoor ground-based mobile phone tower owned by Viom Networks and situated in Kolar, Karnataka, contains one base transceiver station (BTS). The objective of the project was to demonstrate the effectiveness of a Solar / Grid power system (without DG) customized for grid deficit telecom sites. It demonstrated the feasibility of solar as a dependable technology to reduce operational costs and the environmental footprint, making it a win-win for all the stakeholders involved.

Previous Setup

There were two sources of electricity and a battery system in place. Grid electricity was available for only 9 hours and the tower was powered by a 15 kVA diesel generator set for 12 hours.

The battery system was merely used for 3 hours a day and was charged either by the grid or the diesel generator set without a set preference.

The system had an electronic unit that juggled these power sources and matched load to supply. The system also had an SMPS used to regulate the voltage and convert AC to DC (majority of the tower loads require DC).

The Problem Statement

The tower was powered by a 15 kVA diesel generator when grid was not available. Owing to variable load requirements and oversizing, the AC generator operated under sub-optimal load conditions consuming a lot more diesel than needed to power such a load. Secondly, operating a diesel generator under such conditions also leads to wear and tear and needs additional maintenance.

Since this tower was remotely located, transportation of diesel was not a negligible component and contributed to the costs of generating electricity from diesel. This resulted in an extremely high cost of generating electricity using diesel. Analysis and market data points to a cost of INR 60/kWh for grid-deficit and INR 90/kWh for off-grid sites. At this particular site, the cost was estimated to be around INR 59/kWh.

Besides, the electricity supply was variable (mixed 3 phase and single phase supply). The electronic unit that juggled and balanced demand to supply between the different sources of electricity (diesel generator set & grid) had to be able to function under both phases which it was not designed to do. To make full use of grid electricity it had to be left for the single phase supply, which made the set up dangerous to the BTS equipment.

The batteries were another problem. They were used very inefficiently without attention to the charge-discharge cycle or the level of discharge. Their life was considerably reduced leading to high incremental costs of replacement.

Alta's Proposition

Alta's 3rd generation integrated All DC Solar/Grid power system (patent pending) was customized specifically for India. It comes with a static Power Conditioning Unit (PCU) to regulate voltage fluctuations from 110V - 300V to 220V + - 10%. The main controller prioritizes the individual power supply sources and controls the entire power system. When solar power is available, priority is given to power the loads even when grid is available. When power supply from solar array is insufficient during cloudy or rainy days, the grid or battery power automatically kicks in to work in tandem with the solar array.

The -48V 600Ah battery bank has a standby time of 30 hours at (80 per cent DOD) for worst case scenario like damaged power lines, repair after heavy rain.

The main controller is designed with N+1 redundancy, MPPT solar and SMPS modules are designed with quick change concepts. The entire system is based on 14 years of hands-on and in-depth knowledge in design and manufacture of complex embedded systems used in their patented MPPT solar modules.

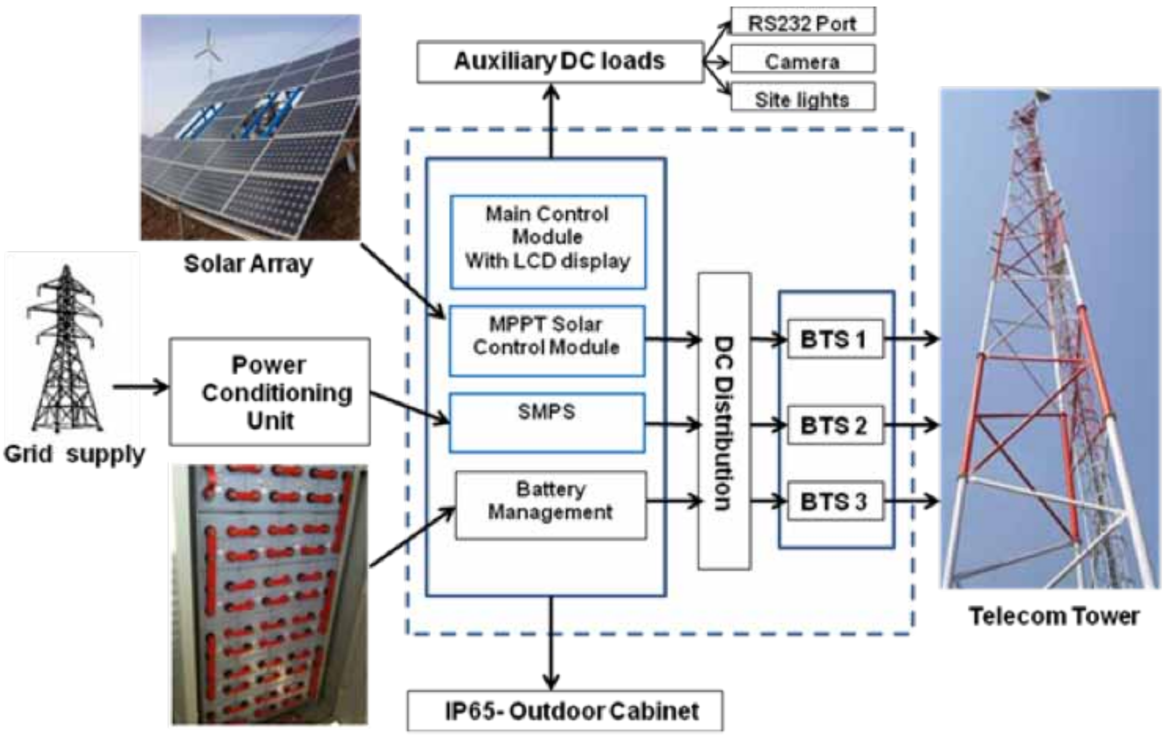
The Solar System

The solar system consists of a 3 kW module unit (16 x 180 W modules), the all-in-one energy controller and 24 2V, 600 Ah batteries. A 15 KVa diesel generator set is also included as a part of the system for extreme emergencies.

Since the supply was erratic (voltage variation from 90-230V), there was a need for a power conditioning unit to stabilize the voltage.

A schematic of the system is shown below followed by a detailed examination of each component.

A schematic of "All DC" Solar / Grid Power System



Tower Load

The tower in question houses one BTS and some ancillary lighting equipment that brings the requirement to approximately 1 kW. This translates to a 24 kWh requirement per day.

Energy sources

The electricity requirement of the tower is provided by three different sources. These are:

A solar grid power system
© Vivek Muthuramalingam / Greenpeace

Grid supply is available for 12 hours at this particular location. Six hours of this is single phase and the other six are three phase supply. Since grid power is the cheapest source of electricity, it needs to be fully utilized. This means that there is a requirement for a phase selector, which would assure complete usage of the 12 hours of grid electricity. This phase selector is present in the heart of the system i.e. the all-in-one controlling unit.

- Solar unit

The solar system consists of a 3 kWp solar array system, 16 x 190Wp solar modules, IP 65 outdoor cabinet to house the main control module, MPPT (Max Power Point Tracking) solar module and US made Eaton SMPS Module; an IP55 cabinet for the -48V 600Ah Sealed AGM VRLA Battery bank. The turn-key solution is specifically designed to operate without a diesel generator.

It has eliminated both capital investment for the DG and the recurring expenses towards DG maintenance, diesel transportation, diesel pilferage and the ever volatile diesel cost. The integrated Solar/Grid system has an operating expense of about Rs 3,000 per month. A similar conventional DG/Grid powered system will cost tower owners about Rs 45,000 / month. The entire turn-key solar solution including battery and remote monitoring comes with a 5-year- warranty.

- Battery System

The battery system was specifically configured to ensure long cycle life; 24 pieces of 2V, 600 Ah cells were used to provide 30 hours of standby time to cater to the worst case scenario. When fully charged, it can power the BTS for 30 hours (80% DOD).

a. The output voltage of battery bank is between 43V and 54V; should a few individual 2V cells malfunction, the battery voltage is within the operating range. When using 6V or 12V cells, the system voltage will be too low to power the BTS when 1 or 2 cells fails. Using 2V cells is a form of built-in redundancy that gives the tower companies time to take corrective action.

b. The cycle life of a battery bank is determined by how the individual cells are matched after the cell activation and formation process. The performance of the 24 units of 2V cells will take on the cycle life of the worst performing cell in the battery pack.

c. The IP55 outdoor cabinet is equipped with a temperature-activated exhaust fan, should battery temperature rise above 35 deg. C.

d. A temperature sensor is connected to the battery management unit and it automatically reduces the charge current during bulk charging, should temperature in the battery bank rise above a pre-set limit.

e. The main controller provides live data of battery temperature, charging and cycling characteristics remotely. Main controller stores this data for 10 years.

f. The lack of updated battery knowhow in the tower industry and the poor grid power quality are the major challenges that adversely affect battery cycle life. High voltage fluctuations, high surges, high current spike, over charge and discharge, temperature and ripple effect may shorten cycle life. (Locally produced sealed AMG, deep cycle batteries are at par with the best AMG VRLA batteries in the world.)

Power Conditioning Unit

The power quality from the grid in semi-rural sites is poor and can vary from 90 V to 300 V. This instability can damage SMPS modules and the sensitive BTS equipment. To mitigate the problem, a customized static power conditioning unit is incorporated to ensure high quality power and fed to the central controller.

Central Unit

The central control unit controls the MPPT, SMPS modules & the battery management unit. It ensures maximum power generation from the solar array. The charge controller ensures that battery is charged correctly and according to manufacturer's charge specifications. The SMPS or rectifier module converts AC to DC and provides a regulated DC output voltage to power the BTS and charge the battery. It is designed with N+1 redundancy to ensure high reliability. The main controller stores the data of the entire power system for 10 years. Through a RS 232 port and a communication modem, clients are able to access the live data from the web.

The power supply is from multiple sources; an intelligent system is needed to ensure the selection of the most appropriate power source. During cloudy or rainy days the solar array power output may be insufficient to power the load requirements. Then the main controller selects the best available power source to work in tandem with the solar panels. The main controller is the brains of the entire turn-key solution.

The diesel cost is only a portion of the total cost, the associated costs like DG maintenance, transportation, battery replacement, all add up to a true cost of about INR 59 / kWh. This does not include the average 20 per cent pilferage. Batteries were previously used as standby and acted as a temporary supply source during a power outage. The rationale in standardisation of the DG to 15kVA is that it is cheaper to purchase in bulk and easier to keep less spares. The other reason for oversized DGs is high starting current of indoor sites with air conditioners (in some cases 7 times). The average diesel consumption for single tenancy sites is about 1.8 litres / hour.

Based on the profile of 12 hours DG runtime, 9 hour grid supply and 3 hours battery discharge, the calculated monthly cost of 1 outdoor BTS site is about INR 45,000/month.

Under MNRE guidelines, a 1kW load system that uses 3kWp solar panels cost about INR 8.1 lakhs with batteries. Alta is offering their turn-key 3rd generation Solar/Grid system at 15 Lakhs. The system includes remote monitoring and 24 hours surveillance system and a 5 year warranty on the entire power system with battery. Alta claims that the operational savings are 90 per cent that translates to a payback period of about 3 years!

CASE STUDY II

3.12 Fuel Cell Driven Telecom Tower in Nagada, MP

Fuel Cell driven Telecom tower in Nagda, Madhya Pradesh

Ballard/Dantherm Power in Asia

Ballard Power Systems is a recognized global leader in the design & manufacture of PEM fuel cells. Ballard announced in November 2011 that Dantherm Power, its backup power systems company, will supply of 30 Hydrogen Fuel cell back-up solution, namely its 2kW DBX2000 systems, for installation at 30 single tenant outdoor sites of IDEA Cellular in India.

IDEA Cellular is part of the $35 billion multinational Aditya Birla Group and India's third-largest mobile services operator. Fuel cell systems will be deployed at cell tower locations in close proximity to an Aditya Birla Group chemical plant in the region of Nadga, Madhya Pradesh. The Aditya Birla Group chemical plant in Madhya Pradesh is a rayon-grade caustic soda manufacturing unit of Grasim Industries. The plant produces a large amount of hydrogen as a by-product, which can be subsequently used in powering telecom towers, as well as in distributed power generation systems within the plant to reduce energy costs and carbon emissions.

For sites connected to the electricity grid that have frequent power outages, Ballard's fuel cells in combination with batteries has completely displaced the use of back-up diesel generators. This initial deployment with Idea Cellular will serve as a first step in validating the financial and environmental benefits of Ballard's fuel cell products to Idea Cellular and to prospects in India.

A fuel cell system, Ballard © Karan Vaid / Greenpeace

A fuel cell system, Ballard © Karan Vaid / Greenpeace

© Karan Vaid / Greenpeace

CASE STUDY III

3.13 Environ Energy Corporation India Pvt. Ltd.

Hybrid SPGS Implementation in West Bengal

Pilot Project for Establishment of Solar Hybrid Renewable Energy System in Shared Mobile Infrastructure of BSNL USO site at Paschim Sripati Nagar in Sundarban Islands.

Project Description

The project was conceptualized and sponsored by the Department of Telecom led by Sri P K Panigrahi, Sr. DDG, DOT with active participation of EECIPL. EECIPL supplied installed and commissioned 10 KWp Solar Power system at a BSNL maintained USO site.

Award of Contract

The contract was awarded to EECIPL on 7th June 2010. The objective was to assess the technical feasibility and financial viability of the SPGS in shared mobile infrastructure.

Site Selection & Pre-installation Scenario

Paschim Sripati Nagar of Sundarban Islands was chosen for the pilot project. This telecom site is located at one of the remotest corners of the country, in the famous Sunderban delta. Due to inaccessible nature and no grid availability, the site had record frequent downtime, with high operational cost due to continuous DG operation which used to be an average of 21 hours/day. Water transport being the only means of communication- transportation and storage of fuel was a major problem. Battery remained partially charged since electric supply was unreliable and was replaced frequently. Due to high DG run, frequent DG breakdowns were common and maintenance was also challenging due to the remote location of the site.

Disaster response was slow and site monitoring increasingly difficult. High levels of carbon emissions resulted in adverse environmental impact.

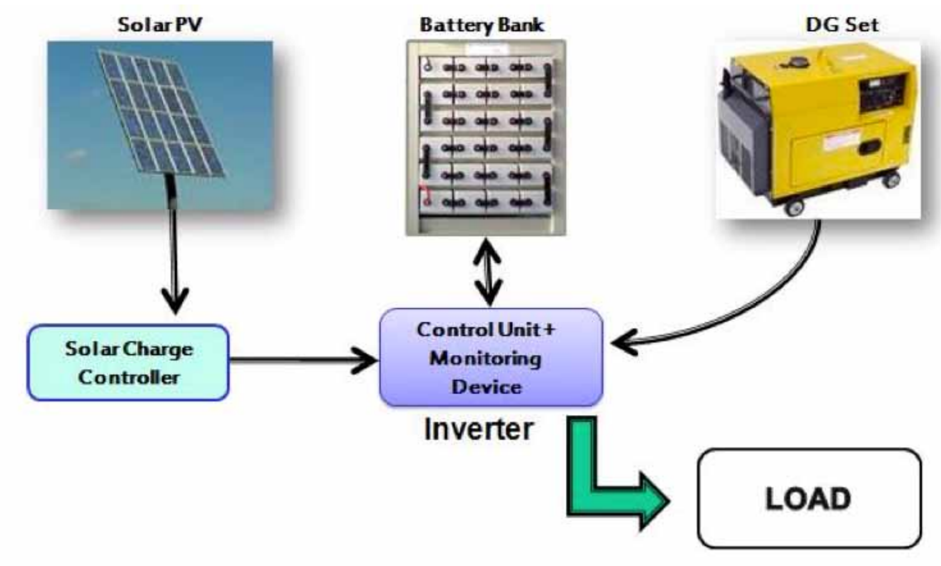
Bhaskar Solar Solution

Engineering Solution by Bhaskar Solar
Design & planning

Sufficient space for retrofitting solar installation is one of the major challenges in most telecom sites. Thanks to the excellent design team of Bhaskar Solar, installation plan accommodated site constraint.

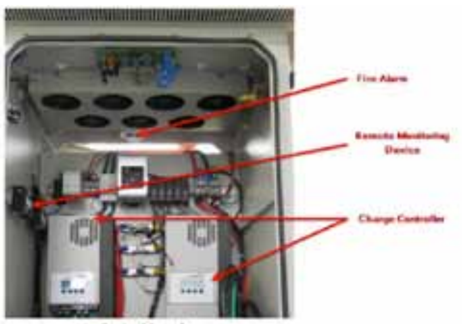
Image source for this case study: Environ Energy Corporation India Pvt. Ltd.

Solar + DG Hybrid System



A unique structure was designed and installed for mounting the Solar panels at a height of almost 30 feet which also catered to the site wind safety factor of 200 Kmph / hour. The Solar panels were so installed to create a shed above the equipments for passive cooling of the outdoor battery bank, control panel, etc, enhancing equipment health and life.

Site Snapshots



Control Panel

Remote Monitoring & Control System

Bhaskar Solar has one of the best monitoring & control system along with a full-fledged NOC to support 24x7 operations. The efficient NOC of Bhaskar Solar ensures proper site monitoring whereby system data is collected every 15 minutes. User automatically receives alerts for low Battery Voltage, low fuel, high room temperature, solar power generation and equipment health. Early alert on fuel and equipment health gives ample time to organize the maintenance activity.

Commercial Advantages

A grossly oversized 20 kVa DG and an extremely remote location in the Sunderbans meant that costs of operations viz. fuel costs, maintenance and logistics were extremely high. The total cost of operations would go as high as Rs 1 lakh a month from Rs 60,000-70,000 contingent on battery and diesel generator set replacements.

With the installation of Solar + DG hybrid solution, DG runtime was drastically reduced from an average of 21hrs / day to 2 hrs /day. Cost of fuel logistics, DG maintenance and consequently, site equipment replacement reduced drastically. Annual Battery replacement cost was also eliminated as the solar solution introduced battery with 5 years warranty.

To better present the practical conditions that existed prior to the solar unit installation, we have taken both best and worst case scenarios under which the site was operating.

Site Specifications

Favourable Case:

Number	Items	Previous Setup	New System	Savings
1.	20 kVA DG Set	16 hours/day	2 hours/day	14 hours/day
2.	Fuel Consumption (2.75 litres/hour)	1320 litres/month	165 litres/month	1065 litres/month
3.	Cost	INR 52800/month	INR 6600/month	INR 46200/month Savings: INR 5,54,000/annum
4.	Carbon Emissions	3537 kg/month	442 kg/month	3095 kg/month

Challenging Case:

	Cost Benefit Analysis: Solar powered site (10 kWp)				
	Scenario (Load Avg 1 kW)	DG operation	Unit	10.0 kW Solar + DG	Unit
	Diesel Cost	38	INR/L	38	INR/L
	DG Maintenance	14.8	INR/h	14.8	INR/h
	DG Life	17,000	hours	17,000	hours
	DG Replacement Cost (Rs.)	14.71	INR/h	14.71	INR/h
	VRLA Per Cell Ah Cost (Rs./cell/Ah)	11	INR/Cell/Ah		
	VRLA Battery Cost (Rs.)	79,200	INR	-	
	Solar Life (Yrs.)	-		25	years
	Daily VRLA Run Hours	3	hours	6	hours
	Solar + Battery Run Hours	-		24	hours
	DG Fuel Consumption (Ltr/Hr)	3.5	L/hour	3.5	L/hour
	Daily DG Run Hours (Hr)	21	hours	2	hours
	Solar Capex (Rs)	-		2,524,600.00	
Cash Expenses	Yearly Fuel	1,019,445	INR	97,090	INR
	Inflationary Adjustments	101,945	INR	9,709	INR
	Yearly DG Maintenance Cost	113,442	INR	10,804	INR
	Yearly Battery Replacement Cost	237,600	INR		
	Yearly DG Replacement Cost	111,208	INR	10,591	INR
	Yearly Maintenance Cost (With Sec)	132,000	INR	132,000	INR

	Scenario (Load Avg 1 kW)	DG operation	Unit	10.0 kW Solar + DG	Unit
	Annual Cash Expense	**1,715,639**		**260,194**	
	Savings	**1,455,445**		**85%**	
	Payback Period	**1.5**	**years**		
	Please note that the profitability with Solar Operation would increase YOY basis due to effect of inflation on Fuel, Battery, Maintenance, DG replacement cost etc.				

Environmental Advantages

Pernicious environmental effects were successfully curtailed by implementing the solar powered model. Reduced fuel consumption led to reduction in Carbon Emission by 68.7 tons per annum.

Particulars	DG Powered Site	Unit	Solar + DG Powered Site	Unit
Daliy DG Run Hr	21	Hrs.	2	Hrs.
Diesel Consumption per hour litre	3.5	Ltr./hr.	3.5	Ltr./hr.
Carbon size	2.83	Kg./ltr.	2.83	Kg./ltr.
Daily diesel consumption	73.5	Ltrs.	7	Ltrs.
Monthly diesel consumption	2236	Ltrs.	213	Ltrs.
Yearly diesel consumption	26830	Ltrs.	2555	Ltrs.
Carbon emission per day	208	Kg.	20	Kg.
Carbon emission per month	6328	Kg.	603	Kg.
Carbon emission per year	75930	Kg.	7231	Kg.
CO_2 Emission reduction per year	68699			Kg.

Present Success Story

The site is now operating on Solar Power for more than 2 years. The site has better uptime, reduced OPEX and is environment friendly.

The success of the pilot project has been acknowledged by both BSNL & DOT.

3.14 TRAI Directive versus the Diesel Elimination Scenario and Conclusions

We discussed the implications of the TRAI directive and the diesel elimination scenario separately.

- The TRAI mandate will still leave 70,000 towers in rural areas consuming 1 billion litres and approximately 128,000 urban towers consuming about 234 million litres of diesel by 2020. It is very possible to reduce this figure to a much lower number, or even zero, and this is what was discussed in the diesel elimination scenario. This is in spite of the fact that the carbon emission reduction as a result of the mandate (emission reduction percentages relative to the base year 2011) will be much higher than what is mandated in the same directive. Therefore, the focus needs to be on the elimination of diesel rather than carbon emission reduction which will follow automatically.

- The MNRE's strategic 5-year plan and targets will clearly not be enough to support the renewable energy installations that will follow as a result of the TRAI mandate leave alone the diesel elimination scenario from the telecom perspective. Therefore there needs to be more allocation on this front.

- Certain energy efficiency measures such as obsolete BTS replacement, elimination of feeder cables and air conditioning wherever possible SHOULD be imposed. These would have the maximum impact on load demand and thus reduce overall electricity consumption.

- If the diesel elimination strategy is pursued reductions in the order of 40 per cent, with 2011 consumption levels as the base, are possible in carbon emissions by 2020. Pursuance of this strategy would result in reductions of 15% by 2012-13, 26 per cent by 2014-15, 36 per cent by 2016-17 and 43 per cent by 2020-21 as far as the 4 lakh existing towers diesel footprint alone is considered[76].

- If the diesel elimination scenario is pursued, the network emissions will be in the order of 22.34 million tonnes1 by 2020 which will be a 11 per cent increase in the carbon footprint levels from 2011.

3.15 Policy Recommendations

Greenpeace recommendation aims at assisting the government, the telecom industry and other stakeholders in the implementation of green telecommunication, that is, to reform regulations to foster competition, innovation, economic growth and important social objectives

The stakes in telecommunication infrastructure development based on clean energy are of crucial importance to the growing Indian economy and the world at large.

The recommendation laid out by Greenpeace aims toward ensuring sustainable growth in Indian telecommunication industry and accelerating its economic development. This recommendation also aims toward sound expansion of telecom network infrastructure based on clean energy.

1. Setting up of realistic but ambitious Renewable Energy target within Green Telecom directive:

Findings in the report clearly outlined that there is strong long-term economic incentive for Indian telecommunication to replace expansive & polluting diesel with economically efficient and clean renewable energy. Therefore, we urge that at least 50% (TRAI recommendations) of all rural towers and 33% of the urban towers should be powered by hybrid power (Renewable Energy Technologies (RET) + Grid power) by 2015, while all rural towers and half of urban towers should be hybrid powered by 2020. This should also be made part of NTP-2012.

2. Compliance Mechanism

For any directive or policy to work on ground effectively, there is need of strong compliance regime incorporated in the directive or policy. We have numerous examples in the country where good legislations were not been effectively implemented because they lack strong compliance mechanism. Therefore, we recommend the introduction of a compliance mechanism with penalty for non-compliance to the obligated entities.

Going with this, TRAI should include financial penalty based on the revenue and levied on the service provider holding CMTS (Cable mode termination system) /UAS (Unified Access Services) /UL license-holder in case of non-compliance of the directive issue by it on any of clause mentioned in Green Telecom directive. In case of recurrent non-compliance by above-mention license-holder, TRAI should recommend cancelation of service license of such holders and Department of Telecommunication, Ministry of Communication & Information Technology should accept such recommendation.

3. Mandatory obligation on transparency and disclosure of carbon emission:

As part of Green telecom directive, all obligated entities should disclose carbon emission of its business operations including network towers owned by itself or by its strategic partners, joint-ventures and network infrastructure providers to TRAI under globally accepted

[76]Current network footprint is at about 16 million tonnes. Elimination of 2.8-3 billion litres of diesel would mean a reduction of 7.4-7.9 million tonnes of carbon emissions, about 45-49% reduction

framework of GHG protocol of World Resource Institute (WRI).

This is the most widely used international accounting tool for government and business entreprise to understand, quantify, and manage greenhouse gas emissions. The base year for calculating all existing carbon footprints should be 2011. The above-said disclosure submitted to TRAI should also be made public by the obligated entities through their company's official website.

All Service providers should reduce 100 per cent and 50 per cent of their absolute emission in rural and urban areas respectively. However, based on the findings of the report's analysis, the exact number on carbon emission reduction target should be 15 per cent by 2012-13, 26 per cent by 2014-15, 36 per cent by 2016-17 and 43 per cent by 2020-21 as far as the 4 lakh existing towers diesel footprint alone is considered.

The declaration of the carbon footprints should be done only once annually by end of September month every financial year. The disclosure of carbon emission should also have plan and strategies to mitigate disclose carbon emission by setting realistic but ambitious carbon emission reduction target with a particular strategy. Direct or indirect off-setting for mitigation of carbon emission can and should only be directed toward additional carbon emission reduction beyond the target set up by the obligated entity.

4. Improving efficiency:

The obligated entity should work with its supply-chain to develop plan for use of energy efficient network equipment within each telecom network site so that overall power consumption should not exceed 500W by the year 2020. Further, there should be an energy efficiency standard for network equipment developed by competent authority with clear timeline for phase-out of non-efficient network equipment. This should be in line with internationally developed and accepted benchmarks for methods in evaluating Energy Efficiency in the national Telecom Networks

5. Sharing of Infrastructure:

There is already an industry norm on sharing passive telecom network infrastructure which should be further developed and actively utilized with higher tenancy within each network towers.

Such obligated entities should be appropriately incentivize for going for sharing of passive network infrastructure sharing. However, TRAI and Telecom industry should also look into possibility of sharing active telecom infrastructure as this gives further economic benefits and reduce growing the carbon emission in long-term.

Greenpeace believe that active Telecom infrastructure sharing should be actively promoted as this will further reduce setting of additional telecom network site and / or reduction of overall power consumption in existing telecom network infrastructure sites.

6. Encourage Entrepreneurship:

By 2020, the telecom energy sector is expected to create more than a lakh jobs. In view of this the entrepreneurial energy India has must be harnessed. It would also encourage venture capital to invest in such start-ups. Going with this Greenpeace in line with recommendation from the working group on telecoms submission recommends that a part of proposed telecom entrepreneurship development fund of INR 2500 crore in 12th plan goes towards Greener Telecommunication in India.

7. Telecom research development fund:

In line with the working group on telecoms recommendation to DOT on creation of Telecom Research Development Fund (TRDF) of INR 5000 Crores in 12th Plan. Greenpeace recommends a part of the fund should go towards enabling greener telecommunication, focusing mainly on R&D and product development in low-emissions in-building wireless solutions. R&D and product development in distributed, renewable and hybrid energy sources for telecom equipment. R&D in energy storage and energy savings.

3.16 Conclusion

The next steps will require a concerted effort by all stakeholders to take measures, at times bold, at times challenging, that will lead to real and lasting change. Right policies will have to be in place, those which promote innovation, eliminate barriers to low-carbon technologies. By adopting ways of measuring energy efficiency and by switching to newer generation renewable energy technologies are industry can truly solve the puzzle. This requires closing the gap between policy and technology.

With dialogue and engagement among diverse group of stakeholders, silos are broken down and a common language around solutions begins to emerge. Telecom sector transition from their energy-intensive physical infrastructure of the 20th century to the innovative clean energy based, connected, information-based infrastructure will truly create the hallmark of the 21st century.

The telecom sector in India holds one of the keys to reaching our climate goals. It is clear that as the energy demand of the telecom sector grows, the supply of renewable energy must also keep pace. Additionally, the sector as a whole should be advocating for strong policies that result in economy wide emissions reductions.

With its immense contribution to India's growth over the last two decades, the telecommunication sector is well placed to move to a business model that relies on energy efficiency measures in combination with resourcing its energy needs primarily and predominantly through renewable sources.

Against this background, Greenpeace is demanding that the telecom industry in India should:

- All telecom companies must give much greater priority to a transparent and more accountable business model and disclose their carbon emission throughout the industry.
- Publicly disclose a roadmap over the implementation of the TRAI Green directive. While sourcing their energy requirements by 50 per cent towards renewable sources by 2015 and phase out diesel consumption completely by 2020.
- To preserve its own economic interest and make long term investment plans for the co-development of renewable energy source for its telecom tower infrastructure and lead the low carbon race.
- Enable a low-carbon economy by playing a significant role in advocating strong climate and energy policy changes in favour of renewable energy sources and technologies at national and international levels.

ANNEXURE I

Annexure 1

Footnote 4

Figure 2
Assumptions

1. Growth in subscriber rates: 15%; Industry reports, EAI Analysis

Footnote 13

1. Average tower in India has a tenancy ratio of 1.7 and houses BTSs that demand anywhere between 1.1-3.3 kW (different configurations based on traffic).
2. Indoor towers will have ACs that demand 1- 1.5 kW. The ratio of indoor to outdoor towers is 60:40.
3. The above two assumptions would translate to an average weighted load of 4.3 kW/ tower.
4. With 400,000 towers, this translates to approximately 15 billion units of electricity. [4.3 kW * 400,000 towers * 24 hours * 365 days which gives around 15 billion units.]

Footnote 18

Assumptions for diesel consumption calculation:

1. Tower distribution and grid availability as mentioned before: 20% in rural areas with average grid availability of 4 hours (rural), 50% with availability of 12-14 hours (semi-urban) and 30% with availability of 18-20 hours.
2. 60% of the towers are indoor implying an air conditioning load in addition to the BTS load and 40% outdoor.
3. Average BTS in rural & semi-urban areas consumes about 1.4-1.6 kW while the average urban BTS consumes about 2.5-3 kW. The average air conditioner would add anywhere between 1.1-1.5 kW to the load demand.
4. 15 kVa generators are used predominantly and the loading pattern has been computed based on the table below.

Footnote 20

Figure 12

Year	Government Burden (in Rs Crores)
2007	8013
2008*	0
2009	36088
2010*	0
2011	9281.8
2012	19974

*- Under-recoveries were borne by upstream Oil companies

Footnote 34

Assumptions for calculating diesel operational expenditure (Applicable throughout the document):

1. Load demand is 1.1 kW on an average for a single BTS outdoor site in rural/off grid areas and about 2.5 kW for single BTSs in urban areas. The demand increases proportionally for 2 and 3 BTS sites.
2. An AC adds about 1-1.5 kW depending on the number of BTSs i.e. 1 kW AC for a single BTS shelter and 1.5 kW AC for a 3 BTS shelter.
3. Since diesel generator sets are already present in telecom sites and we are looking at replacement primarily, their capital costs are not considered for the return analysis.
4. 15 kVa generator sets are considered since these are the most prevalent.
5. For diesel consumption at different load levels, the table below was used. This was obtained from secondary research and industry interviews.
6. Market Price of Diesel: Rs 45/litre
7. Average maintenance cost: Rs 12/hr
8. Transport Cost of Diesel: Rs 1.5/litre
9. Escalation in operational costs including escalation in price of diesel: 5% annually
10. We have not considered pilferage for business case evaluation
11. Cost of grid electricity: Rs 7/unit
12. Grid price escalation: 3% annually

Load %age ---> Capacity of Generator(kVa)	10	15	20	25	30	35	40	45	50	55	60	65	70	75	Above 75
15	1.3	1.7	1.8	1.8	2	2.2	2.2	2.2	2.2	2.3	2.5	2.7	2.9	3	3.52

Footnotes 34, 35, 36 & 37

All the following values have been obtained from industry inputs, interviews and also with the use of internal resources.

Allied Equipment Required

- SMPS: Rs 45,000
- Power Management/Interface Unit: Rs 75,000

Solar

- Cost of Unit: Rs 1.6 lakhs/kW
- Capacity Utilization factor: 16%
- System Annually degradation: 1% annually
- Useful life: 25 years
- Area required per kW: 8 sq. m
- Insurance cost: 0.35% of Capital cost
- Inverter lifetime: 12 years
- Inverter price reduction: 2% annually
- O & M expenses: 0.75% of Capital cost
- O & M escalation: 5% annually
- Subsidy: 30% of capital cost

Financial Assumptions

- Depreciation: 80% for the first year, 5% for next two years
- Cost of financing: 13%
- Marginal Tax Rate: 33%

Battery (Same for existing unit prior to solar)

- 600 Ah Battery: Rs 1.4 lakhs/unit ($5/Ah approx.)
- Life of Battery*: 5 Years

- Standard discharge: 10 hours (0.1C)
- Peukert's Constant: 1.3
- Battery backup: 8 hours
- Battery configuration designed as per autonomy requirements.

*- Battery needs to be monitored carefully for operating temperatures and charging-discharging cycles to maximize life

Note:

Charging efficiency of the battery is 25-35% i.e. to discharge 1 kWh of electricity, the battery needs to be supplied with 1.25-1.35 kWh.

Biomass

- Minimum Biomass System size: 10 kW
- Capital Cost: Rs 80,000/kW
- Capacity Utilization factor: 75% for small scale systems
- Useful life: 20 years
- Feedstock cost: Rs 2.5/kg minimum and variable
- Charcoal production: Rs 0.05 kg/kWh
- Rate of Charcoal: Rs 10/kg

Operational Parameters

- Feedstock required: Rs 1.5 kg/kWh for small scale systems
- Feedstock transport cost: Re 1 /tonne-km
- Feedstock escalation: 3% annually
- O & M expenses: Rs 0.6/kWh
- O & M escalation: 5% annually

Financial Assumptions

- Depreciation: 80% for the first year, 5% for next two years
- Cost of financing: 13%
- Marginal Tax Rate: 33%

Fuel Cells

- Capital Cost: Rs 1.75 lakhs/kW
- Fuel Cell Efficiency: 50%
- Useful Life of unit without stack: 15 years
- Life of Stack: 8000 hours
- Stack cost: 40% of capital cost
- Stack cost reduction: 2% annually
- Required hydrogen for electricity: 77 gms/kWh
- Cost of hydrogen: Rs 150/kg
- Logistics cost: Rs 150/kg
- Hydrogen price escalation: 2% annually
- Hydrogen logistics reduction: 3% annually

Financial Assumptions

- Depreciation: Straight line method
- Cost of financing: 13%
- Marginal Tax Rate: 33%

Footnotes 38, 45

The following values have been obtained from industry inputs and interviews after extensive primary and secondary research.

Assumptions common to the two scenarios:

- Assumptions made in diesel consumption and electricity calculations viz. annexures for footnotes 13 & 18 also stand good for this. This would, in specific, pertain to

a. Indoor to Outdoor tower ratio (60:40)
b. Tower distribution and grid availability.
c. The average AC load has been assumed to be 1.4 kW.

- Furthermore, for the purpose of simplicity, we have clubbed rural and semi-urban areas together for our analysis. Therefore:
  a. An average rural & semi-urban BTS would demand 1.4 kW while the corresponding urban BTS would demand about 2.5 kW.
  b. The ratio of towers in rural & semi-urban areas to urban areas is 70:30.

- The tenancy for rural and semi-urban areas is 1.5 and that in urban areas is 2.5.
- Tower growth over the next 8 years is 6%.
- New towers will be powered by a hybrid of renewable energy sources and grid. Therefore, there will be very little or no diesel consumed on their behalf.

Assumptions for the TRAI Directive

- The average demand of the cooling system falls by 8% annually.
- The rural and semi-urban tenancy ratio increases by 5% annually while the urban tenancy ratio increases by 3% annually.
- The power demanded by BTSs decrease by 7% annually. This would serve to lower the demand created by new towers and new tenants.

Assumptions for the Diesel Elimination scenario

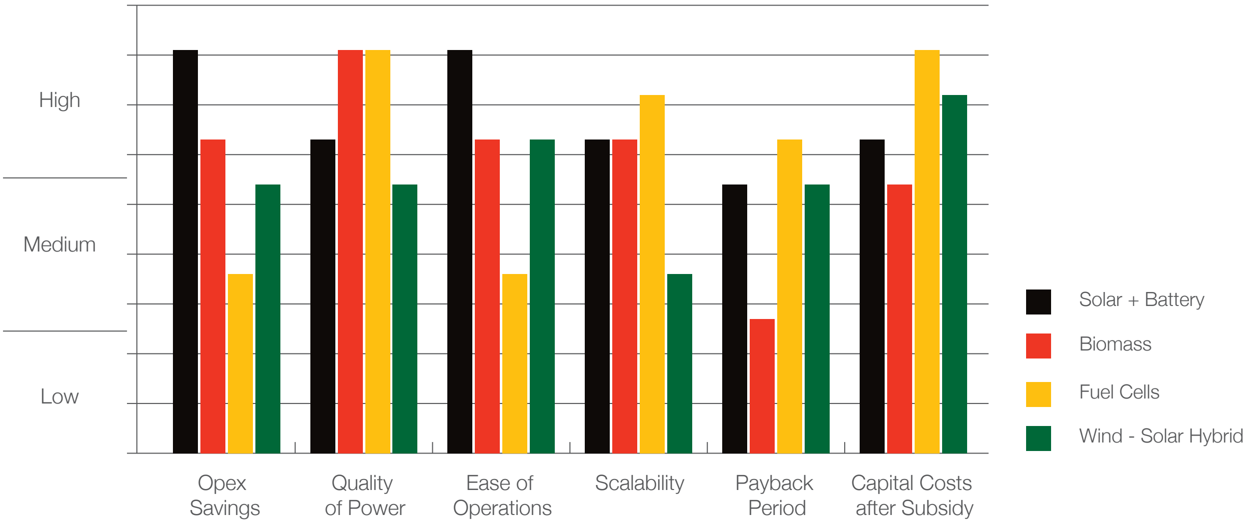
- The average demand of the cooling systems falls by 11% annually on the back of conscious efforts by operators.
- The rural and semi-urban tenancy ratio increases by 5% annually while the urban tenancy ratio increases by 3% annually.
- The power demanded by BTSs decrease by 7% annually. This would serve to lower the demand created by new towers and new tenants.

ANNEXURE II

Annexure 2

A comparison of the different renewable energy technologies on the suitability of their use in telecom sites is summarized below. :

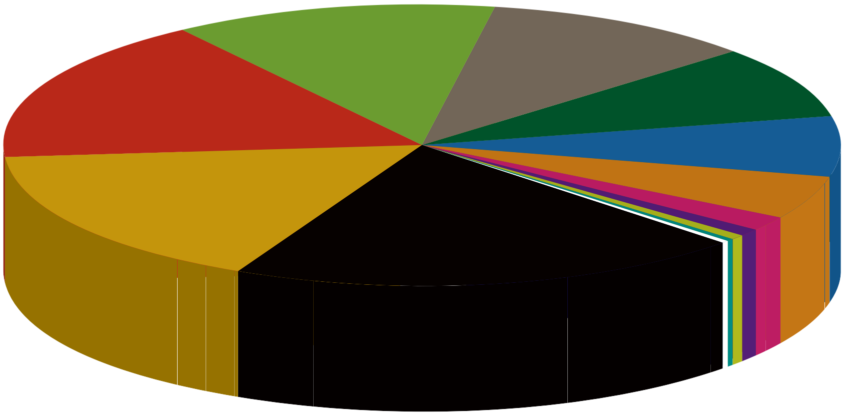
Figure : A Comparison Of Technologies In The Telecom Context



Telecom Growth Snapshot

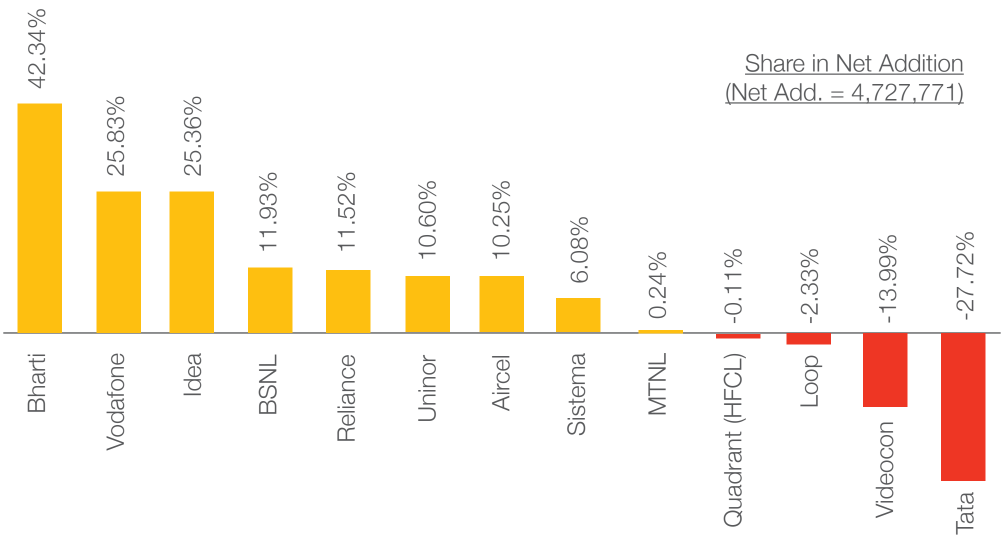
Subscribers	Total	Wireless	Wireline
	965.52 millions	934.09 millions	31.43 millions
Growth % from previous quarter	Total	Wireless	Wireline
	0.48%	0.51%	-0.33%
Urban Subscribers	Total	Wireless	Wireline
	621.76 millions	597.59 millions	24.17 millions
Rural Subscribers	Total	Wireless	Wireline
	343.76 millions	336.51 millions	7.25 millions
Overall Teledensity	Total	Wireless	Wireline
	79.58	76.99	2.59
Urban Teledensity	Total	Wireless	Wireline
	169.03	162.46	6.57
Rural Teledensity	Total	Wireless	Wireline
	40.66	39.80	0.86

Source: Telecom Regulatory Authority of India – as of 30th June,2012



Source: Telecom Regulatory Authority of India – as of 30th June,2012

Vodafone 16.46%
Reliance 16.55%
Bharti 20.05%
Idea 12.54%
Quadrant (HFCL) 0.16%
Loop 0.34%
MTNL 0.60%
Videocon 0.60%
Sistema 1.77%
Uninor 4.88%
Aircel 6.95%
Tata 8.59%
BSNL 10.52%



Source: Telecom Regulatory Authority of India – as of 30th June,2012

Table VI-A: Commissioning status of Towers (State-wise) as on 31.03.2012 in rural & remote areas for provision of mobile services

S.NO.	State	Number of Districts	Number of Mobile Towers to be set up	Number of Towers Commissioned
1	Andhra Pradesh	22	596	596
2	Arunachal Pradesh	12	67	64
3	Assam	20	87	87
4	Bihar	37	453	453
5	Chhattisgarh	16	553	553
6	Gujarat	4	59	59
7	Haryana	8	12	12
8	Himachal Pradesh	11	258	258
9	Jammu & Kashmir	12	81	81
10	Jharkhand	18	273	273
11	Karnataka	26	381	381
12	Kerala	11	46	42
13	Madhya Pradesh	45	933	933
14	Maharashtra	33	956	956
15	Manipur	9	98	68
16	Meghalaya	7	107	107
17	Mizoram	8	43	37
18	Nagaland	7	51	48
19	Orissa	30	434	434
20	Punjab	3	14	14
21	Rajasthan	32	403	403
22	Sikkim	3	6	6
23	Tamilnadu	27	327	327
24	Tripura	4	115	115
25	Uttar Pradesh	66	653	652
26	Uttranchal	13	184	184
27	West Bengal	16	163	163
Countrywide Totals		500	7353	7306

*- The number of towers is subject to change based on actual field survey and coverage achieved thereof as per the terms and conditions of the Agreements.

Table VI-B: Commissioning status of Towers (IP-wise) as on 31.12.2011 in rural & remote areas for provision of Mobile Services

S.NO.	Name of Infrastructure Provider	No of clusters	Number of Mobile Towers to be set up	Number of Towers Commissioned
1	RCIL	5	407	403
2	QTIL	1	88	88
3	GTL	4	410	410
4	KEC	4	381	375
5	BSNL	63	5758	5721
6	VODAFONE	4	309	309
TOTAL		81	7353	7306

GLOSSARY

ARPU	Average Revenue per user
BCCH	Broadcast Control Channel
BSCs	Base station controllers
BTSs	Base transceiver stations
CEA	Central Electricity Authority
CUF	Capacity Utilization Factor
DC	Direct Current
DCDG	DC Diesel Generators
DG	Diesel Generator
DoD	Depth of Discharge
DoT	Department of Telecom
GDP	Gross Domestic Product
GW	Gigawatt
GWh	Gigawatt-hour
JNNSM	Jawaharlal Nehru National Solar Mission
kVa	kilovolt-ampere
kW	Kilowatt
kWh	Kilowatt-hour
MNRE	Ministry of New & Renewable Energy
MoU	Minutes of Usage
MSCs	Mobile switching centres
MW	Megawatt
MWh	Megawatt-hour
NOC	Network Operating Costs
OMC	Oil Marketing Company
PCU	Power Conditioning Unit
RET	Renewable Energy Technology
RPO	Renewable Purchase Obligation
TPP	Trade Parity Price
TRAI	Telecom Regulatory Authority of India
USO	Universal Service Obligation
VC	Venture Capitalist
YoY	Year on year
CMTS	Cable Mode Termination System
UAS	Unified Access Services

Greenpeace is a global organisation that uses non-violent direct action to tackle the most crucial threats to our planet's biodiversity and environment. Greenpeace is a non-profit organisation, present in 40 countries across Europe, The Americas, Asia and the Pacific.

It speaks for 2.8 million supporters worldwide, and inspires many millions more to take action every day. To maintain its independence, Greenpeace does not accept donations from governments or corporations but relies on contributions from individual supporters and foundation grants.

Greenpeace has been campaigning against environmental degradation since 1971 when a small boat of volunteers and journalists sailed into Amchitka, an area north of Alaska, where the US Government was conducting underground nuclear tests.This tradition of 'bearing witness' in a non-violent manner continues today, and ships are an important part of all its campaign work.

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