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SUSTAINABILITY CHALLENGES AND INNOVATION STRATEGY IN GREEN TELECOM-A REVIEW OF TELECOM INFRASTRUCTURE IN INDIA

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ABSTRACT

The Indian Telecommunications sector a multi-billion dollar industry, commanding a colossal billion plus subscriber base is known to be major reckoning force in India's Gross Domestic Product (GDP) growth trajectory. Bolstered by the liberal market dynamics and reformist economic policies and regulatory framework, many national and international telecom network operators and service providers were strongly vying for the burgeoning subscriber base. With profitable urban markets reaching near saturation with regard to market size and penetration, the telecom market players are working hard to make their rural stint a success. Confronted with several infrastructural and operational challenges, these telecom players are driving innovation and devising strategies to advance their rural market penetration as a strong sustainable strategy. The article examines the stream of Telecom Infrastructure in India in depth and discusses the various attributes that forms its backbone. The paper determines the Infrastructural and operational growth challenges encountered by the telecom players in the Indian market. Their sustainability and green technology practices that are helping in resolving their infrastructural issues and development has been analyzed and presented. The planning and prioritization strategies necessary for the success and sustainability of such a programme are discussed. Several initiatives by major telecom companies have been discussed.

Keywords: Telecom Infrastructure in India, Sustainability in Telecom, Green Telecom in India, Energy Efficiency in Telecom, Solar in Telecom

1. INTRODUCTION

Over the momentous Last two decades, the Indian telecommunications market has seen exceptional growth, catalyzing and catapulting the country into world's top high growth

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

economy by contributing substantially, about 6.5% (2018) to an expected contribution of 8.2% (2020) (KPMG, 2017) to the country's Gross Domestic Product (GDP).The sector has spearheaded the country into encompassing world's second largest telecom subscriber base (Ibef, 2019). The Indian government's market deregulation and proactive regulatory policy made the telecom industry highly competitive, enabling the sector to evolve as country's one of the top sectors of growth and a top employment generator by promoting inclusivity and equitable economic opportunities by bridging the digital divide. India, touted to be world's most price competitive market, with affordable low tariffs and declining mobile handset rates ensured that the subscriber base increased exponentially. With launch of National Telecom policy (in 1999 & 2012) the tele-density zoomed past from 2.8% in 1999 with 1.5 million subscribers to an impressive 91.82% with colossal 1.2 billion subscribers (TRAI, 2019).The policy was the stepping stone for the massive infrastructure expansion in the form of developing nation-wide telecom networks for both wire-line and wireless telephony consecutively catering to the connectivity requirements of the users. The vast infrastructure roll–out comprising of active and passive infrastructure led to infrastructural costs with high capital expenses (CapEx) and with rising energy consumption and energy costs led to high operating expenses (OpEx) therefore resulting in overall high Total cost of ownership (TCO) for the telecom players. As per TRAI, the Telecom business's biggest recurring cost is its mammoth energy bill mainly due to its use of expensive Diesel, making it the second spot holder only next to the Indian Railways the biggest Diesel consumer in India. The falling Average revenue per user (ARPUs) owing to low tariffs and price wars, aggressive cut-throat competition, declining handset costs, new technology 3G/4G/5G, roll-out etc has produced a lot of pressure on the telecom industry's overall performance. Furthermore, with the profitability at its lowest and several other challenges of rural markets has shaped sluggish growth of tele-density in these areas. With the overall industry growth momentum marred by a near saturation and over exploited urban tele-density and a sluggish Industry wide growth, the telecom players were constantly challenged to devise innovative and green sustainable practices to advance their infrastructure in rural areas. The climate resilience and preparedness driven by the natural calamities as the utility grids generally plummet during adversity (the recent example of Jammu and Kashmir floods that washed away the grid completely) is also driving the green technology adoption as the solar/wind powered systems usually withstand such situations. Also, being future ready for the new technology for next generation data networks [4G - Voice over LTE service(VoLTE), 5G, WIMAX, IPv6, VoWi-Fi, Fibre to the Home (FTTH),Internet of Things (IoT),Robotics, Artificial Intelligence (AI) ,Machine to Machine learning (M2M) Augmented Reality (AR),Virtual Reality (VR), In-building solutions (IBS), distributed antenna systems (DAS)] and the Indian Government's ambitious aim of achieving 1 billion unique telecom subscriber base on a fast track through projects like Digital India, Smart cities, National Optical Fibre Network (NOFN), etc. while

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

keeping control on their operational costs. The Indian government's commitment to United Nations' 2015 global climate deal and sustainable development goal of carbon emission reduction is majorly driving the green initiative for combating climate change. Therefore, the government has also supported these green and sustainable initiatives, as Telecom Regulatory Authority of India (TRAI) issued guidelines in 2012 promoting research, design and development in advanced green technologies followed by releasing a consultation Paper on Approach towards Sustainable Telecommunications in 2017 for promoting carbon emissions reduction through the adoption of green technologies in telecom infrastructure. With policy regulation and business need favouring the need to go sustainable inevitable, sustainability will be key strategy in telecom industry. This paper explores the current telecom infrastructure in India and the challenges it faces. The paper evaluates the latest technology backed Sustainable and Innovative solutions available for addressing these challenges in developing markets. It also explores the sustainable, Innovative and scalable solutions and measures adapted by the telecom players in India.

2. BACKGROUND-TELECOM INFRASTRUCTURE IN INDIA AND THE NEED FOR SUSTAINABLE INNOVATION

Building suitable telecommunication infrastructure has the similar upshot on growth of telecommunication as the telecommunication services have on growth of the market economy (TRAI, 2011). The next focal point of growth for telecommunication in India was the fast track network expansion. Following which the industry witnessed significant growth and churnings in the technology sphere, migrating from Wire line to Wireless; dial up internet connection to broadband connection, Wi-Fi hotspots; data downlink speeds from 56 kbps to 2-100 Mbps; Voice usage to Data usage; 2G, 2.5G to 3G, 4G (LTE) and so on. With rapid telecom growth, the dynamic business models evolved swiftly from mobile operator companies' (OpCos) setting spotlight on increasing their subscriber base to transitioning towards marketing their service offerings. Presenting customers with flexible "experiences" rather than long-term services has changed the manner telecom service providers adjoin their telecom infrastructure planning to customer service deployment (Nolle, Techtarget 2009).Previously, a strong level of vertical integration among operators was a popular conventional Industry strategy for the cellular network operations (Meddour et al, 2011).However, with the emergent operational complexities and an expeditious technology platform up gradation, from 2G to 3G and 3.5 G wireless technologies followed by 4G technologies including LTE, the scenario is transitioning away from the traditional format (Informa Telecoms & Media, 2010). Consequently, the scope of Telecom Network infrastructure has transitioned from just one role player to a distributed model with three main role players- where Telecom/Mobile Network operator companies' (OpCos/MNO), outsource their non-core activities of Network roll out to Telecom Original

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

Equipment Manufacturers (OEMs) and Telecom Infrastructure service providers to focus more on Customer service centric activities.

Figure 1: Created based on concept by Meddour et al (2011)

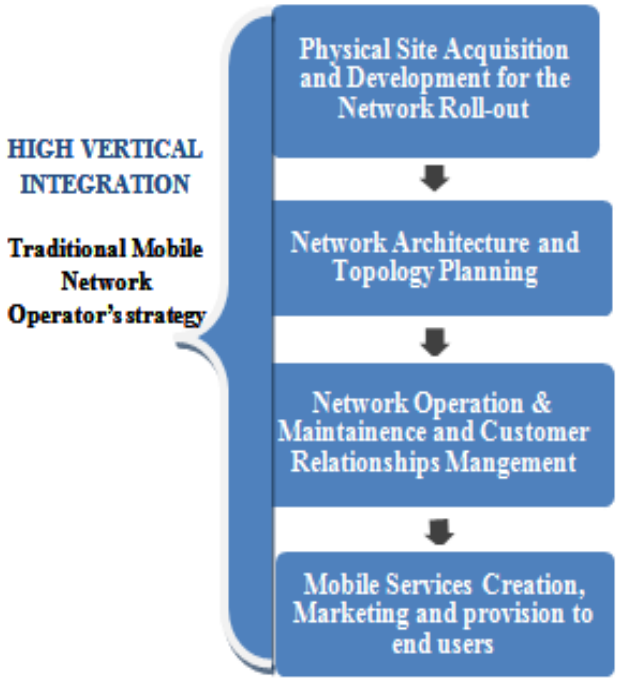
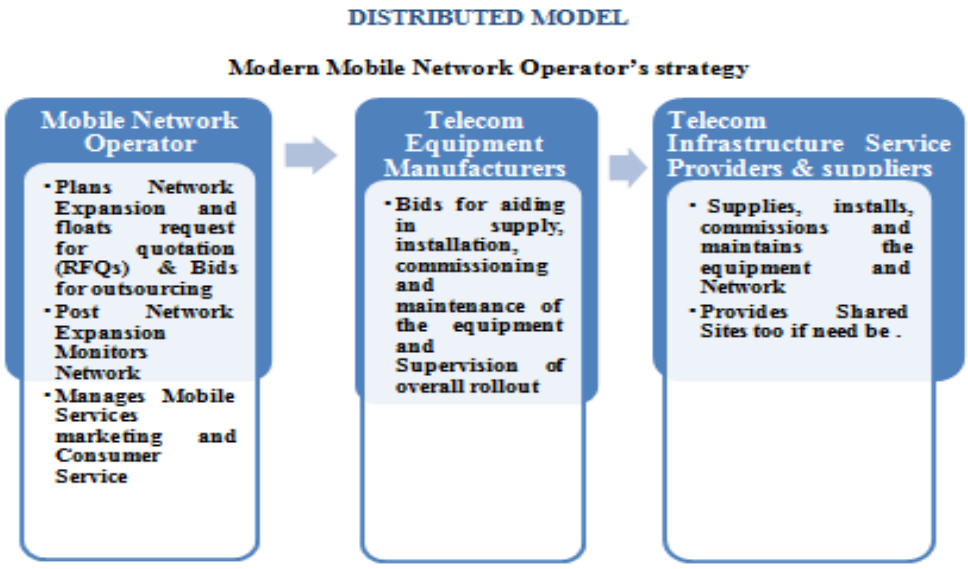


Figure 2: Author's own Compilation



ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

The Telecom network is divided in total 22 circles in India.GSM is the dominant technology with almost 80% subscriber base. As per TAIPA, in 2013 inspite of having over 200 IP-1 players in the market, 7-8 players owned over 75% of the Telecom Infrastructure. Since, the Telecom companies aimed at focusing more on their core operations; therefore they segregated their tower infrastructure assets into separate tower infrastructure companies. These tower companies have helped telecom companies in lowering their operating expenses, improving their capital structure and have also provided an additional revenue stream for their business. Thus, a new business category in telecom was created the Telecom infrastructure providers, which was formalized by DoT's as Infrastructure Providers category 1 (IP-1) policy (TRAI, 2017).Consequently, Indus Towers was created as the world's topmost tower Infrastructure Company in 2007, by a joint venture between Airtel, Idea and Vodafone and with its recent merger with Bharti-Infratel, it has become even bigger. The Indian success story has inspired several operators across the world in replicating the business model of towers business.

Table 1: Top Telecom Companies in India (Author's own Compilation)

Operators Companies	Equipment Manufacturers	Infrastructure companies
Vodafone- Idea	Huawei	Indus Towers- Bharti Infratel
Reliance JIO	Ericsson	American Tower Corporation
Bharti Airtel	Nokia-Siemens	GTL Infrastructure
BSNL	Alcatel- Lucent	Reliance Infratel
Aircel	ZTE	Tower Vision India

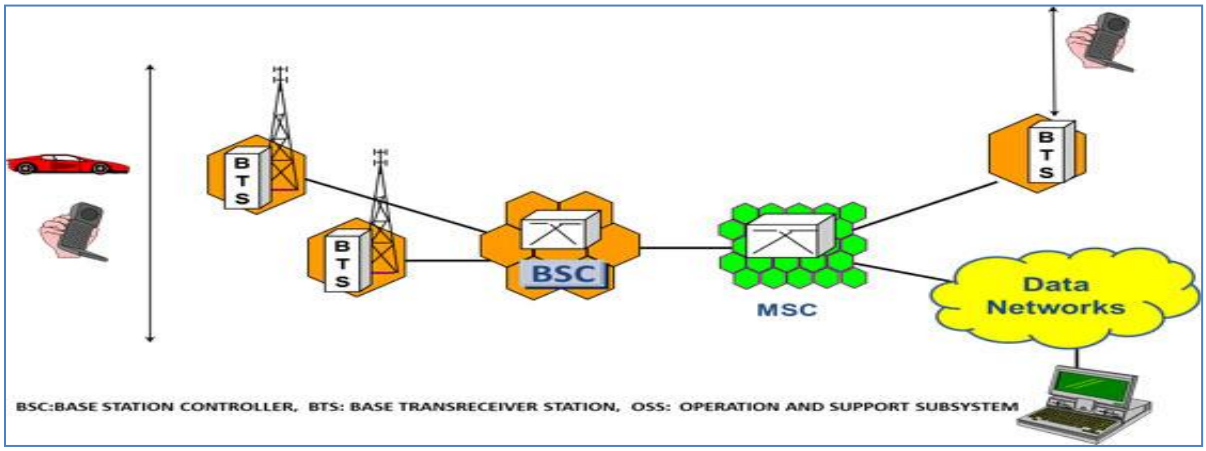
The need for building up network infrastructure deployment for wireless technology is primarily propelling the growth expansion in the Telecom infrastructure business. A wireless cellular site network infrastructure/architecture consists of a combination of Active and Passive Infrastructure that form the physical network elements. Passive infrastructure is made up of non-electronic equipment for example site space, buildings/shelter and easements, Mast/Tower, Power Supply, power backup, Air-conditioning (Aircon) and Electricals. Active infrastructure consists of collection of electronic components and facilities including transceivers [Base Transceiver Station (BTS)], controllers [Base Station Controller (BSC)], Switches [Mobile Switching Centre (MSC)], routers, registers, antennas and Power systems. A Base Transceiver Station (BTS) is the main access point that drives the radio communications between cell phone and network functions, by aiding in encoding and encryption of speech, multiplexing (TDMA), and

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

modulation & demodulation of the radio signals. Further, Base Station Controller (BSC) handles multiple BTSs by managing radio channels allocation, administration of frequency and power and several other functions. The main centre of a GSM network is the Mobile Switching Centre (MSC) that apart from doing the basic switching functions operates the crucial call routing & setup functions of the network. (COAI, 2015)

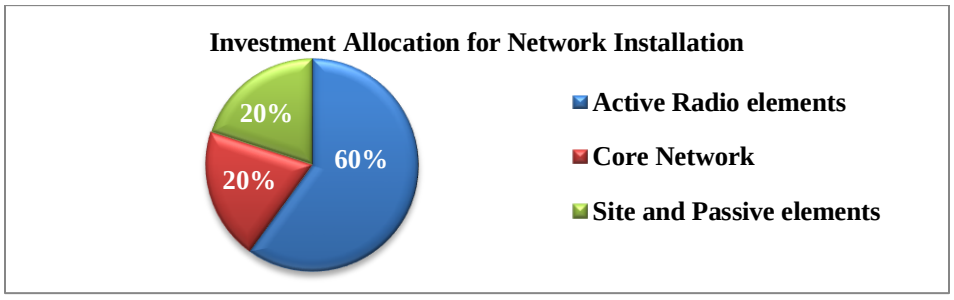
Figure 3: Layout of few of the main components of a telecom site



(Source: Cellular Operators Association of India, 2015)

As per Mason (2010), in emerging economies, 87% of the total capital expenses (CapEx) are contributed by the three salient elements, including 41% contributed by civil and site acquisition and design, followed by 31% power, and 15% by BTS/Node B, whereas 69% of the total operating expenses (OpEx) are contributed by four key items 20% by Hardware & Software support, 20% by Power , followed by 15% by Land rent and Backhaul contributing 14% expenses. Meddour et al (2011) depicted the CapEx of a typical 3G network site with active elements forming 60% of major share of expenses.

Figure 4: The investment allocation of 3G network deployment



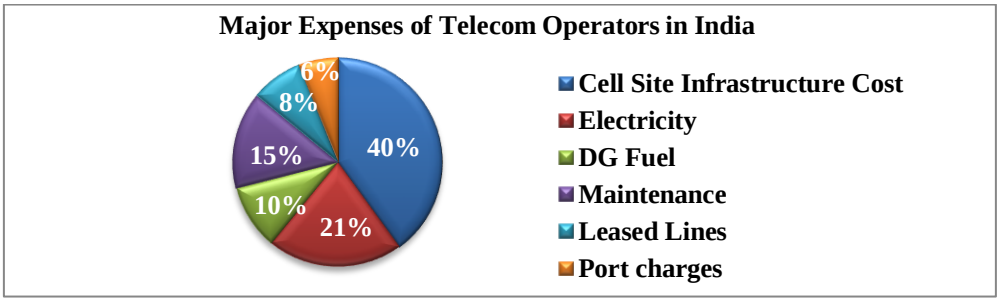
(Source: Meddour et al, 2011, Computer Networks)

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

In contrast to emerging markets in general, Energy and Diesel expenses formed a substantial part of the total costs involved in a setting-up and operation of a site of Telecom companies in India (Mathews, 2012). Also, an annual 2.6 billion ltr of Industry's Diesel consumption had caused substantial burden to the country's exchequer of $1.15 billion annually with 5 MTs of Co_2 emissions. (TRAI, 2011)

Figure 5: Major Expenses of Telecom Operators in India



(Source: Mathews COAI, GSM.COM 2012)

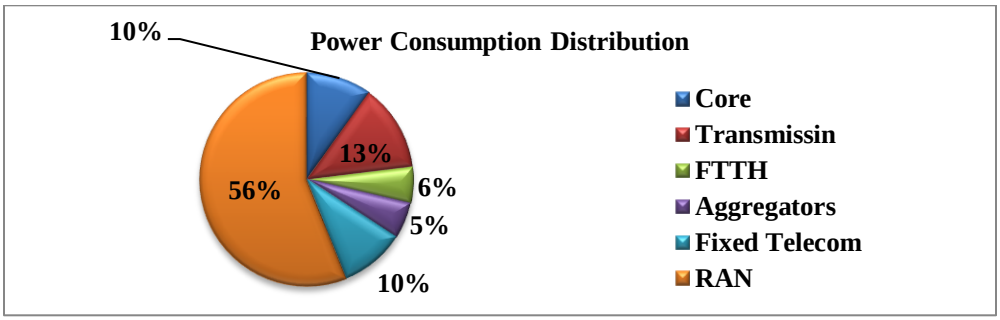
In India, an average cost of a telecom tower development varies between 10-15 lakh, though its CapEx varies from urban to rural areas depending on rental and the other costs. The majority share about two-thirds expenses are on incurred on the Network costs a substantial part of the Telecom operators' overall OpEx (Gadgetsnow, 2011). Of this two-thirds Network cost, the Energy expenses formed the biggest part around one-third of the total operating costs, about 5 to 8% of the net revenue per call is exhausted due to the energy costs.

According to the Deloitte report in 2015, the India telecom tower industry was projected to increase at 3 percent compound annual growth rate (CAGR) over the next four to five years to around 1.2 million. As the per TAIPA, this figure touched 5.85 lakh in 2013 from1 lakh towers in 2006; covering more than 90% of the country's land area. As per Ministry of Communications and IT, the number of BTSs was even higher with a total of 7,36,654 base transceiver stations (BTS -2G GSM and CDMA & 3G Mobile Towers) as recorded in Nov 2012 (Telecomtalk, 2012). In 2017, the base stations deployments doubled in numbers to over 15.94 lakh in number, though towers numbers reduced to 4,52,000 (DoT,2017). However, the Tower numbers picked up again in May 2018 to 461,000 mobile towers, with around 1.8 million base tower stations (BTSs) (Business standard, 2018). In 2018-2019, COAI claimed a jump in the number of BTSs with total 20 lakh units now in over 5 lakh mobile towers across the country.

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

Figure 6: The distribution of power consumption across the telecom access network



(Source: Telecommunication Engineering Centre, Department of Telecommunications, GOI)

According to TRAI, among the components of the mobile network, the base station alone consumes around 59% of the power in the network followed by mobile switching centres at 21% and the core transmission at 18%. In the current scenario, the maximum 67% of rural Network's power demand is met by diesel and only in the 33% demand is sufficed by utility power. The site power consumption can be optimized by better network planning, effective infrastructure sharing, adoption of energy efficient technologies with renewable energy sources and judicious utilization of available power. As the data transmission requirements in the networks doubles every five years, and around 71% of the carbon emissions in the Indian telecom sector are on account of site power usage, hence containing power utilization in telecom networks would be the cornerstone of any green telecom strategy. (TRAI, 2011)

3. TELECOM INFRASTRUCTURE GROWTH AND SUSTAINABILITY CHALLENGES

Telecom network operators have constantly encountered several operational and deployment challenges of matching their technology and infrastructure to related service opportunities to facilitate revenue generation. The telecom network operations costs have seen a high ascent due to the complexities involved in next-generation technology based network, and moreover finding the required skill set for the integration and maintenance of the network infrastructure is turning out to be ever more difficult (Nolle,Techtarget 2009).With a soaring subscriber churn rate, lowest average revenue per user (ARPU) in the world, a high debt burden (estimated to be nearly Rs 8 lakh crores) declining voice revenues, low spectrum, congested networks with high subscribers per megahertz spectrum, are several challenges that are putting Indian telecom companies (telcos) in a tight spot.(Joshi, Livemint 2014)

3.1 Falling ARPU & Revenue- The Indian Telecom Industry is touted to have ARPUs that are lowest in the world, with declining voice revenues (about Rs.0.19 per minute) and world's

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

lowest data tariffs with Rs.18.5 for 1 GB or even lesser of data. While the consumers have benefited, the operators are facing a tough challenge of lean operating margins due to declining ARPUs, accompanied by currently world's highest increasing Minutes of Usage (MoU). The falling ARPU is primarily the consequence of declining call rates owing to competitive pricing thus enhancing lower income strata affordability. The Indian telcos operate on the low tariff – high volume model and their income are alike of their counterparts operating on high tariff – low volume models. However, profit margins have declined sharply equally for public and a private sector, though the higher decline is for the state-owned companies, especially during the period between 2016 and 2018.The Tower industry lost huge on the tenancy revenues and growth as several major operators shut down business or merged. Furthermore, TRAI reduced the Interconnect Usage charge (IUC) for the voice calls by over 57% (from 14 paise to 6 paise minute) in 2017, and will completely abolish it by January 1, 2020 (TRAI, 2017). The IUC cut has further made a huge dent in operators' margins and profits due to reduced revenues. Mobile Number portability has also dented the operator's customer base thereby reducing revenues.

3.2 High Tax- A high regulatory cost of about 25% of total revenues was being borne by the Indian Telecos that discouraged the private investment (Joshi, Livemint 2014). However; apart from paying a high licence fee, in case of spectrum acquisition, the operator has to additionally pay other spectrum related charges (spectrum allotment and radiowaves usage charges). The telecom Tower companies were levied with Property Tax and excluded from GST' Input Tax Credit system. Further the high GST has augmented the existing financial burden.

Table 2: Taxes and Levies on Telecom Industry (Author's own compilation)

Taxes and Levies on Telecom Industry	
Spectrum Usage charges	3% -5% of Adjusted Gross Revenue (AGR)
License fees	8% of AGR
Goods and Services Tax (GST)	18%
Universal Service Obligation Fund	5% of Revenue
Interconnect Usage charge IUC (between operators) A source of revenue	To be abolished from January 1st, 2020

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

3.3 High Competition- In 2010, with the entry of 3G players, there was an increased pressure on revenue pertinent due to infused competition in the market, with every circle having 10-12 players, each competing for a market share. But, with the 4G services launch with Reliance JIO's entry in 2016, this competitive dimension has gone to another new level. Several small telecom players shut down from the market due to severe price wars. Even major operators got a jolt, such as Tata Teleservices' acquisition, Aircel and Reliance Communication shutting operations due to falling revenues and severe losses whereas Vodafone and Idea merged to sustain. With Mobile Virtual Network Operators (MVNOs) using Wi-Fi hotspots and companies likes Google, Microsoft, Facebook, WhatsApp, Skype and multiple start-ups and renowned companies offering cloud services, the sector today faces even more fierce challenges.

3.4 Poor Infrastructure- The grid penetration growth initially was not at par with the tele-penetration. The Poor infrastructure was due to limited or non-availability of power supply and uncertain grid power system (load shedding etc) leading to increased downtime and poor accessibility (roads & connectivity etc) to reach hinterland. This increased the complexity to reach and provide infrastructure in 6, 00, 000 villages, where in 2011 there was no utility power connectivity in about 20% of the villages. Now the situation had improved with Indian government's full electrification claim in April 2019, though quality, infrastructural and intermittent poor supply bottlenecks remain.

3.5 Low Rural Penetration- Urban India has reached a maturity level with tele-density of 161.34%, therefore the opportunity lies in the rural India with only 55.90% tele-density (TRAI, 2019). Low revenues coupled with High CapEx (grid non-availability/Poor quality, high diesel consumption and high costs of RETs) that is required to set up infrastructure that supports rural areas which not only lacks basic infrastructure but also shortage of skilled personnel, which further acts as a hindrance in deployments. Over 62,443 Indian villages remain untapped by rural telephony's reach. (IBEF, 2019)

3.6 Expensive Next-Generation Technologies- India is running behind schedule and lags behind the world in rolling out the new generation technologies such as the 5G. 4G technology adoption in India has not been at par with expectations as yet, whereas the world industry has already leapt to 5G. There are few challenges in the future outlook of next-generation networks such as the slow 4G adoption coupled with the steeply priced 4G-enabled devices, and lack of regional content in local/regional languages (Joshi, Livemint 2014). The major challenge and concern is the heavy cost of investment coupled with low investment returns.

3.7 High Price of Smartphones and Tablets- The Smartphone is a medium for telcos to increase ARPU by providing data services. In the semi-urban and rural population that are low-income groups, the data usage cannot see an upswing in the absence of wide-spread availability

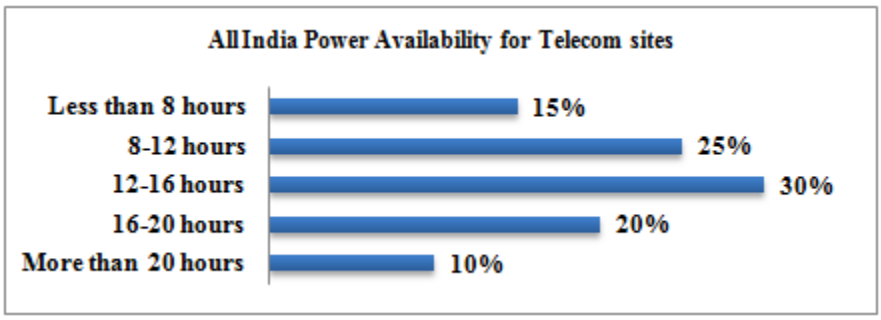
ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

of reasonably priced smartphones and tablets at a entry level price point levels of about 2,500 to 5,000 Indian Rupees. (Joshi, Livemint 2014)

3.8 High Operational & Capital Expenses (OpEx & CapEx)- High operational costs due to Inadequate power supply, high costs of backup power, theft of diesel, low availability, high CapEx (equipment, energy and realty costs) & accessibility of alternative power solutions are key challenges faced by telecom companies (Datamatics). Fuel pilferage & manipulation of passive infrastructure equipments erodes the bottom line & also increases the operational costs. On an operational level, network sites' energy management is a major concern due to escalation in grid-based power and diesel costs (India Infrastructure, 2014).

Figure 7: Power Availability at Telecom sites in India



(Source- TRAI 2017)

There is high diesel dependency for operation and running equipment and cooling infrastructure as about 40% of rural India towers are with near negligible power. As per an industry estimate in 2017, 75% towers fall under weak grid and 10% towers were off-grid category, only 15% towers fall under reliable grid category (Bloomberg, 2018). There is sizable difference in the cost of running by both mediums grid power unit costs about Rs 6 to Rs 8, whereas running a DG is double the cost with Rs 12-Rs 14 per unit, further with diesel pilferage cost added this cost may shoot four times to Rs 22-Rs 26 per unit. Inspite of having a special 21% subsidy for the Telecom industry, the unreliable utility power, fluctuating fuel prices, transportation, pilferage and theft has made Diesel an expensive option with operational costs raised to almost 100% in last 5 years. In 2013, the Government assessed that, 5.85 lakh towers with 8 hours of average daily Diesel Generator operation with 8760 litres of diesel use per site yearly will guzzle almost 5.12 billion litres of Diesel annually and this is an enormous cost considering that this doesn't include the Diesel consumed during transportation & lost due to pilferage. While telecom site's average diesel costs forming about one-third of the total operating expenses, however in rural areas diesel & energy costs have jumped to almost 50 percent. Fuel pilferage/theft is another common problem; the industry estimated that the electricity and Diesel pilferage costs in almost

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

50% sites amounted to Rs 2,200 crores yearly till 2014 (DNA, 2014). Presently, Diesel costs take away almost 7 to 10% of Telecom Operators revenue. The telecom Industry's cumulative Diesel bill costs the industry Rs 90 billion annually. (Business Standard, 2018)

3.9 Delays - The industry faces several issues related to delays in spectrum auctions, 5G launch, policy delays, interference and approval delays on the part of local municipalities and various departments caused by the lengthy process of getting clearances. Also due to the prevalent perception about harmful radiation emitted by Towers are causing severe health hazards, the industry faced stiff opposition from the RWAs for removal of network infrastructure from residential areas and roof-tops.

3.10 Low Spectrum availability – In India, there is low spectrum availability per subscriber 0.2 MHz per operator on average, though the spectrum costs are one of the highest in the world. The spectrum availability is about a quarter of the global average, even lower than its Asian counterparts Bangladesh (37.4 MHz) and Malaysia (75 MHz).The operators in India possess significantly smaller amount of spectrum, approximately 13 MHz on average, compared to international standards (COAI, 2015).Therefore, the current spectrum bands are insufficient to cater for growing subscriber demand.

3.11 Health & Environment – In 2012, the Department of Telecommunications (DoT) had issued guidelines on the Electro-Magnetic Field (EMF) emissions from wireless telecommunication, lowering the EMF exposure threshold to 1/10th of the ICNIRP exposure level denoting that the Indian standards are 10 times sterner compared to most other countries. Also, audits are conducted by the Telecom Enforcement Resource & Monitoring (TERM) cells, on the self-certification provided by the operators. An amount 5 lakh INR penalty was imposed per BTS per Operator for non-compliance (DoT, 2012).This penalty was increased to 10 lakh INR in 2013.As per the telecom ministry a total penalty of 10.80 crores INR was recovered from defaulters from 2013 to May 2016 and during year 2015-16 (April- December, 2015) imposed fine of Rs 323.56 crores on the industry.(ET,2016)

3.12 Carbon Emissions- Climate change and global warming due to Co_2 emissions is a severe global threat. The Telecom industry dependency on a fossil fuel such as Diesel is leading to carbon emissions. In 2011, TRAI estimated that a 10-15 kVA capacity diesel gensets consumed 2 litres of diesel per hour producing 2.63 kg of CO_2 per litre, amounting to about 7 million tons of CO_2 carbon emissions by network and device embedded equipment contributed about 25% to emissions. In 2011, the total CO_2 emission from Telecom industry was approximately 20 million tons (average 18kg per subscriber), which was 1% of the total ICT emissions in India; higher than the global telecom industry's average of 0.7%, averaging about 8 Kg emission per subscriber. The diesel consumption and its consequent carbon emissions are bound to increase

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

further with new network rollouts and upgrades for rural expansion and 4G/ LTE/BWA services. (TRAI, 2011).In 2014-15, the telecom sector's carbon emission were 58.3 million tonnes, driving this increase to almost 70% over three years between 2014 to 2016. (TRAI,2017)

Table 3: Estimated Carbon Emissions from Telecom Equipment.

S.NO	Network Elements	Total Carbon Emission (in Tonns)	Total Carbon Emission (in Tonns)
1	BTS	13 million	
2	BSC	1.3 million	
3	MSC	0.1 million	
4	Exchanges	6 million	
5	Network Controllers Transmission	.08 million	
6	Core & Servers	.05 million	
	Total	20.5 million	1904 million
	Percentage Co_2 Emission of the total	1%	

(Source: TRAI, 2011)

3.13. The telecom industry is facing some other concerns like low PC Penetration, High cost of broadband compared to Voice, Unavailability of localized content in vernacular language, Non availability of sufficient back-haul capacity, quality of services for instance call drop, and under-investment in passive infrastructure etc.

Therefore, it is indeed a critical point for the entire telecom industry to tackle these challenges in a sustainable manner and downsize them before they escalate into major hurdles for the sector in future.

4. WAY FORWARD SUSTAINABILITY STRATEGY-GREEN TELECOM AND BUSINESS INNOVATION.

Sustainability and innovation has grown into a vital strategy for all businesses today including Telecom, as it is helps effective resource and cost optimization, building competitiveness besides leading to environmental sustainability and corporate social responsibility. The government is

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

promoting the cause of Green Telecom, with a release of consultation paper on Approach towards Sustainable Telecommunications in February 2017. As per TRAI, the key essentials of Green Telecom Networks encapsulates the carbon footprint assessment and reduction, energy consumption minimization by energy-efficient technologies and protocols adoption in telecom networks, transitioning from fossil fuels to renewable energy sources, eco-friendly fuel alternatives and framing a carbon credit policy.

Table 4: Department of Telecom (DOT)'s direction on implementation of Green technologies

Focus Group	Activity	Year & Scope/Target
Towers	Hybrid power (Renewable Energy Technologies (RET) + Grid power) deployment	2015-Rural 50% and Urban 20% 2020-Rural 75% and Urban 33%
All Network's products, equipment's and services	Green Passport [GP]" certification	By 2015- Certified by Telecommunication Engineering Centre (TEC) based on Equipment's Energy Consumption Ratings
Service providers	Carbon footprint Declaration	Twice in every Year- Declare carbon footprint of Network Operations to TRAI
Service providers	Voluntary Code of Practice adoption	To reduce carbon footprints adopt energy efficient technologies and Network Planning, infrastructure-sharing and deployment of Renewable Energy Technology.
Service providers	Carbon Credit Policy (2011-2020)	Formulate a policy to achieve carbon footprint reduction From base year 2011 - Rural a maximum of 50% reduction by 2020 -Urban a maximum of 66% reduction by 2020
Service providers	Carbon emission reduction targets	Aim for carbon emission percentage reduction in all mobile networks from base year 2011-2012 By the years 2012-2013- 5% ;2014-2015-8%; 2016-2017-12%; 2018-2019-17%; 2019-2020-30%; 2022-2023-40%

(Source: TRAI, 2017)

4.1 Green Technology and solutions for Telecom Infrastructure.

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

4.1.1 Alternative (Renewable) Energy- In 2013, it was estimated that over 70 percent of the 585,000 telecom towers in India were in semi urban and rural areas that face power cuts of more than 8 hours or have no electricity at all. So as to keep the telecom towers functional 24X7 in an environmentally friendly manner, the tower industry has been focusing on novel ways of optimizing energy and driving away the dependency on diesel generators for back-up. With the diesel prices, steeply rising in last few years, the cost of generation has soared. As a result, the tower industry has rolled out renewable energy solutions, such as solar, wind, Pico-hydro, bio-diesel, natural gas, bio-fuel and Fuel cell as well as hybrid combination, have been deployed to provide power to the telecom towers in electricity deficit areas. Renewable Energy Technologies (RETs) use for powering network operations is also to be ramped significantly to a level of around 25% by 2020 (TRAI,2011). In 2014, merely 1% of the total tower sites were solar powered. The Solar energy usage can help in reduction of 30% to 60% in overall energy expenses by bringing down diesel dependency. An average one KW Solar Power system prevents 136 kg carbon emissions as well other NO_2 and SO_2 emissions and saves about 68 kg coal and 568 litres water (Bhatnagar and Panigrahi, ITU 2013) A lightweight wind turbine can be incorporated into the existing infrastructure in coastal areas, can bring 50 per cent reduction in diesel consumption at remote rural sites and up to 100 per cent at repeater sites (Tele.net,2017) .An off-grid full solar site' payback period in based on its diesel consumption alone is about 4 to 5 years (TRAI, 2017). Moving a 3 BTS outdoor site to Renewable energy could possibly save 15554 Kg Co_2 emissions and 9000 units (kWh) electricity annually. (Greenomics,2018)

Table 5: Site backup for 8 hours or 24 kWh/day equivalent of back-up power for an outdoor site with 3 kW load with Renewable energy

Type of Renewable Energy	Renewable Capacity Installation and Efficiency	Cost of Renewable & Accessories (in INR)	Total Cost (in INR)	Life Expectancy (in Years) and Maintenance	Carbon Footprint
Solar Photovoltaic (SPV) Solution	8kW with 1720 Ah @ 48 battery 19.7%	Solar-8,25,593 Battery-5,15,996	13,41,589	Solar-20 Battery-3 Minimal Maintenance	Zero at point of use
Wind Power Solution	10kW with 1634Ah @48Volts battery 20%	Wind-10,00,000 Battery-4,90,196	14,90,196	Wind-20 Battery-3 Minimal	Zero at point of use

ISSN: 2455-8834

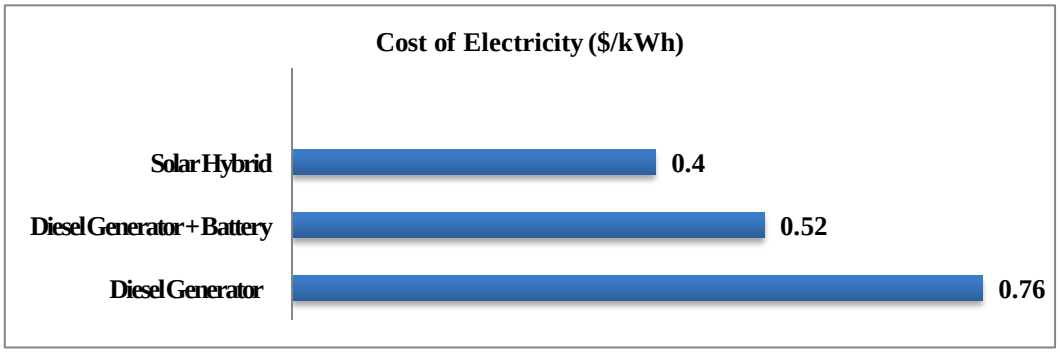
Volume: 04, Issue: 05 "May 2019"

				Maintenance	
Biomass Solution	10kW/No battery required 20%	Biomass-11,00,000 Biomass cutter-50,000	11,50,000 (Plus Maintenance Cost 40 INR/day)	Biomass fuel cost and plant maintenance	Minimal
Hydrogen Fuel Cell Solution	4kW/No battery required 20%	Fuel cell-8,80,000	8,80,000 (Plus Cost of hydrogen Transportation	Full Cell- 15 to 20 Stack life- 10,000 Operating hours (claimed by vendors) Hydrogen fuel cost and System Maintenance	Zero at point of use

(Source: Intelligent Energy, 2013)

As per Bloomberg and Facebook estimates, for off-grid towers the Solar hybrids Telecom power solution (a combination of solar, diesel generator and batteries) will be about 53% cost-effective than diesel gensets power generation option for telecom operators in India. As seen in figure below

Figure 8: Electricity cost generation as per fuel type for Off-Grid towers



(Source: Bloomberg, 2018)

4.1.2 Better technology and Network Planning- The technological revolution is lead by constantly evolving professional grade high efficiency energy management products duly aided by R&D in bringing down the overall costs. Furthermore, several other OPEX reducing measures are being adopted by the operators like network cost optimization and hiving off network & infrastructure provisioning such as towers business into separate business units, consequently improving competitiveness thereby attracting considerable investment.

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

4.1.2.1 Improving Efficiency- Improving the power efficiency of Passive equipment such as Power backup equipment such as Battery, DC Power systems, Power Integrated Unit (PIU) and Diesel Generator, will help in saving operating costs and reduce carbon emissions. There is availability of improved battery sets that consume almost one-tenth of what was consumed earlier. Diesel run time can now be cut to four hours or lesser; DC Diesel Generator and Site Monitoring and Control system (SMCS) are such energy efficient solutions.

1.1 Power Consumption Reduction-

1.1.1 Business Innovation-

Active and Passive Infrastructure Sharing- Operators are ensuring operational efficiency by sharing a built tower instead of building a new one. The new and competitive service models of active and passive consumption is already bringing consolidation in the telecom sector, where mobile network operators and infrastructure providers are joining together to better utilize their spectrum and infrastructure (Sinha, Communications Today 2016). Potentially seen as a viable medium for far reaching broadband services accessibility for a higher number of underserved communities in the world, Mobile infrastructure sharing may enhance the mobile broadband deployment, and also fuel the migration to newer technologies (Lefevre, 2008). This sharing model is a mutual win-win preposition as it is leading to faster expansion of the reach of network coverage, bringing down infrastructure & operational costs, reducing duplication of work, and perk up profitability by way of financial savings. Active Sharing can help reduce 30-35% of the telcos capital expenditure and operating expenditure by around 5%. Tenancy ratio per tower - the operators /tenant's numbers with their antennae and active infrastructure – after initial fall in tenancies due to exists and mergers, the site occupancies are projected to grow from 1.37 in 2018 to 1.55 by 2022, primarily due to an increase in data services. (ICRA, ET 2019).The Tower sharing measure has helped the industry in making substantial savings of about Rs. 23,000 crores in CapEx value between the period from 2006 till 2018 (Communications Today,2018). Also the site sharing has brought operational efficiencies in Diesel consumption, every day on a site by per tenant in 2011-12 about 7.34L of diesel was consumed, which dropped to 4 litres in 2015-16 as per TAIPA.

1.1.2 Improved Existing Equipments- Earlier Separate BTSs were used for 2G, 3G and 4G technology, are being substituted by Next Generation all in one technology single base-station that needs to simply change the radio configuration. The BTS has developed to be more efficient, with reductions in average power consumption by about 60% within five years from 2007 to 2011. Also the use of outdoor Base Transceiver Stations can reduce diesel cost as indoor sites with air conditioners, consume 40% more energy on account of ACs (Gadgetsnow, 2011).There are Efficient energy storage solutions to optimize energy usage as high efficiency batteries such

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

as Li-ion batteries, advanced VRLA batteries and Intelligent TRX feature that reduces battery's power consumption during low traffic, helps in cutting down on Utility bills. "Intelligent" antennas (that consume less power by assessing customers' bandwidth needs) can be deployed as it allocates only the required transmission capacity. A combination of all some of these equipment can make a Diesel Free site, which may be a combination of batteries and cooling units.

1.1.3 New Equipment Introduction-Optimized Efficient Cooling solutions such as DC free cooling unit (FCU), Simple power panels, solar cooling units and Green shelters could be employed to significantly bring down Diesel costs. Further, Green Tower, Integrated Power Management System (IPMS), Gen X, Fuel optimizers and Fuel catalyst could as well be adopted to optimize energy consumption.

Table 6: FICCI – A.T. Kearney Report- Green Telecom: The Way Ahead 2012

Typical reduction in CO_2 emissions and Diesel savings per year per site			
Measure	**Typical Annual reduction in CO_2 Emissions for a given site**	**Typical Annual Diesel saving for a given site**	**Annual Diesel savings in Rs. (per site)**
Passive Sharing	10.5 tons	3,500 liters	150,000
Outdoor BTS	4 tons	450 liters	19,000
Next Generation BTS	3.5 tons	450 liters	19,000
Intelligent TRX	2 tons	200 liters	8,500
Solar Energy	8 tons	3,000 liters	126,000
Battery Improvements	4 tons	1,500 liters	63,000
DC Diesel Generator	3.5 tons	1,300 liters	54,500
DG Improvements	2.5 tons	900 liters	39,000

(Courtesy: COAI, GSM.com)

1.1.4 Optimized Intelligent Network Planning and Design- Several alternate deployment architectures in term of new network design methodologies, radio techniques and site technologies can be applied for urban, rural, indoor and outdoor sites for better efficiency. A single unified core, optimized energy efficient radio network, a blend of micro and macro sites, integrated all-IP communications platform, a shared RAN, environment friendly shelters and structures for housing of BTS / BSC equipments, Power efficient low power BTS, Tower top mounted outdoor BTS adjacent to the antenna array, upgraded firmware with powers saving features, remotely monitoring diesel generator runtime and fuel consumption, dynamic energy management control and monitoring, site energy management software, are few indicative strategies and energy efficient technologies, that could be applied to plan a greener network.

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

With customised combinations of solar and energy management products, the DG running hours can be reduced from 17-18 hours to 4 hours (or in a few cases even zero) to achieve overall 40-50 % OpEx savings. (Gadgetsnow, 2011).

4.1.3 Spectrum sharing or Network cooperation (NetCo) - The guidelines on spectrum trading by TRAI are pushing the sector towards consolidation. This will push industry towards optimum spectrum utilization and tower infrastructure, and an enhancement in the services' quality. Since spectrum sharing with combined blocks of spectrum will create opportunities for better network performance efficiency with reduced number of towers, and immense cost savings as multiple operators will share a network.

4.1.4 Automation-Telecom Infrastructure companies are emphasizing the automation the monitoring & management of its tower footprint & enable proactive asset maintenance for achieving higher uptime of a site or circle, reduced energy costs, lower OpEx, easy operation and maintenance, which can improve maintenance efficiency and avoid penalties. Effective efficiency in daily operations & asset management for margin improvement is the current need of the industry. Therefore, a real-time analytical engine and unified intelligent network management platform is an inescapable requirement for the telecom infrastructure service providers (Datamatics). A Remote Management Systems (RMS) can deliver up to 10% energy savings, leading to savings of 1116.9 million kWh, equivalent to more than 9,38,000 tonnes of CO_2 reductions.(TRAI,2011)

4.1.5 Service models-Outsourcing- Novel outsourcing strategies are being explored by the telecos as Information Technology enabled resources are progressively becoming a crucial element of the telecom infrastructure, for creating flexible service lifestyle processes and in network integration and management support (Nolle, Techtarget 2009).The non-core activities' outsourcing and adoption of cost-effective business models have helped improve the operators' ROI even on low ARPUs. Renewable Energy Service Companies (RESCOs) can be encouraged to set up renewable energy plants for telecom / tower operators eager to subcontract the energy component at network sites. (COAI, GSM, 2012)

4.1.6 Innovative Solutions- Innovatively camouflaged (mobile towers) smart poles have emerged, that blend well with the surrounding landscape to maintain aesthetic appeal, enabling pervasive network coverage in a Smart city situation. These smart poles are not only fitted with micro-cell equipment for mobile network services, but also have CCTV cameras for surveillance and security of the surrounding areas (Sinha, Communications Today 2016). More Wi-Fi hotspots and small cell sites, increasingly used by telcos to decongest networks.

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

4.1.7 Green manufacturing, Green buildings and Waste disposal are other important elements of the Green telecom strategy

5. SOME INITIATIVES FOR SUSTAINABLE & GREEN TELECOM BY INDUSTRY PLAYERS.

The telecom sector has adopted the GSMA Mobile energy efficiency initiative, which provides operators with information and best practices to enable them to reduce the carbon footprint (COAI GSM, 2012). According to Ministry of New and Renewable Energy official, nearly 1.2 lakh diesel free sites have been deployed and 20,000 solar sites are being worked upon in India. (Communications Today, 2019)

Table 7: Sustainable and Green Initiatives of Major Telecom companies (Author's own compilation)

Company and Initiative	Achievement
Bharti Airtel Network Improvement Initiative 'Project Leap'	-By 2017-18, Migrated its 62500 sites to Green Technology (battery- hybrid, lithium-ion, FCU, SCU (Solar Cooling Unit) and low power technologies) with 25% reduction in energy requirements -In last 5 years reached total 1 MWp capacity rooftop solar at main switching centres sites and saved total 2,300 million tons of Co_2 emissions. -Procured over 90 million green units per annum through power agreements and 73,000 tonnes of CO_2 emission per annum reduced. -In last 5 years, 30% reduction in power consumption with low power consuming BTS and in 2017-18, 25% reduction with 91% outdoor BTS sites -Adoption of New Green Tower design and architecture without diesel generators -Reduced diesel dependency with 60% Network sites on a zero footprint architecture with no air conditioning. -Aim a 70% carbon emission reduction target with solar and new battery technologies and double Green telecom towers. -Aims to increase the core sites' use of renewable energy (solar/wind/hydro) – to achieve > 65 GWH/Annum of green energy. -In 2016-17, over 2400 tons and in 2017-18, 2900 tonnes of IT and network infrastructure e-waste was recycled.
Vodafone Sustainable Recycling initiative	-Under the initiative, LEED certified offices in 2012 Lucknow, in 2013-14, Platinum Certification for Delhi office and Gold Certification for Mumbai corporate office. -From 2010 till 2014, deployed renewable energy in 405 off-grid and poor grid sites reducing DG runtime by 75%; hybrid solutions hybrid solutions with intelligent controllers

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

'ReSolve'	in 3,000 sites saved diesel consumption by 50%; 17,580 sites declared as Green Sites; Free Cooling Units (FCU's) eliminated air-conditioning at 1,000 indoor sites; 1,700 owned sites converted from indoor to outdoor, including 11,539 partner sites, the conversion reduced 57,000 tonnes of CO_2 emissions. -In 2012-13, adopted renewable energy at 146 off grid BTS sites, Through the energy conservation measures saved by 4.8 million liters and 8,500 tones Co_2. -In 2013-2014, 161 sites adopted solar power and 729 sites converted indoor to outdoor and eliminated the use of ACs at, saving 17% about 2,542 tonnes Co_2 emissions -Green Datacenter- In 2013-14, Virtualisation saved of 54.43 GJ of energy and 12.4 tonnes of carbon emissions; Database Consolidation saved 94.6 GJ energy and 21.5 tonnes of carbon emissions; Database Optimisation 1,104 GJ of energy and 251.4 tonnes Co_2 emissions; Power Policy optimised power use and saved 10,048 tonnes carbon emissions annually and Datacenter cooling optimised saves 53,918 GJ energy yearly -In 2013-14, through Video Conferencing sessions reduced of 15,762 tonnes of CO_2 emissions. - Under RESOLVE , in 2013-14, over 2,365 tonnes hazardous waste was disposed and recycled responsibly
Idea Cellular Carbon Reduction Programme 'Green Idea Programme'	-70% of BTS are Outdoor (25% reduction in Energy consumption compared to Indoor BTS). 7,500 indoor sites converted to outdoor sites in 2017-18 and 17,000 sites in 2016-17 reduced cumulative carbon emissions by 1.4 lakh tons. -1,200 solar sites with collective installed capacity of 5.4 MW, also RET based generation through PPAs, is approx 8.25 MW. -In 2017 & 2018, reduced 43,692 tons of carbon emissions each year Power Purchase Agreements and indoor to outdoor conversions -In 2017 & 2018, DG running reduced by 4 hours per BTS, saving approximately 2 Million Lts diesel each year. Also reduced more through improving PUE (Power Utilization Effectiveness) at MSC Locations. -Using energy Efficient Datacenter with PUE 1.80 -Did 5 site trial runs of solar hybrid methanol-based fuel cell systems in association with the United States Trade Development Agency - Did 5 site trial runs for bio-fuels (made from plant-based fuels from non-edible cotton and jatropha) in association with the in association with the GSMA and Ericsson
BSNL	-Installed world's largest solar-powered green mobile network with 1836 mobile towers in ten states funded by USOF -Planned to install 6,673 towers for Green network in difficult and uncovered terrain of north-eastern states. -In 2019, Under RESCO model, installed 65KW grid connected rooftop solar plant on its office building in Kerala and plans to add its 12 buildings in the state for this model. The 505-kilowatt peak (kWp) capacity plant will produce 7.4 lakh units per year saving 600

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

	tonnes of Co_2 emissions. Under the RESCO model, it had deployed solar in its 9 office sites in eastern Uttar Pradesh and plans another 11 buildings, savings about 20 tons of Co_2 emissions yearly. In 2017, Similarly, in Madhya Pradesh 2.55 MWp with 148 solar plants at Exchange Buildings had been planned. -In 2016-17, Installation of 100 Nos. 5 kWp solar photo voltaic systems (SPV) at BTS sites in Kerala -Adopted "Project Ojas" in 2018 for energy conservation, with software based energy charges optimization; DG sets Optimization – One set for a group of 20 sites in urban and 10 sites in rural areas; renewable / non-renewable sources powering of non-electrified BTSs; ACs replaced by Turbo Ventilators for cooling BTS; RESCO model for renewable Energy and Online monitoring of Initiative at corporate office -Under Energy conservation Policy 2010 saved Rs 615 crores from 2010 till 2015-16, Rs. 164 crores in 2016-17 and under "Project Ojas", Rs.77.82 crores (34.36% of BSNL target) between April to September 2018.
Indus Towers	- 67544 diesel free green sites, saving 210 Ml of Diesel since 2011-12, by investing 350 crores INR in energy initiatives each year since last 5 years. -Implemented simple power panels and solar cooling units at its sites. -1100 renewable energy sites, aims to cover 50% of all telecom sites by the year 2021. -More than 100000 sites AC Free (with free cooling and solar cooling units) -Over last 5 years, Halved its diesel consumption and reduced 565 million tons CO_2 emissions -Ran a pilot site with a fuel cell system as replacement for DG (Proton Exchange Membrane-system a mixture of methanol and water replace) in Delhi. -By the year 2021, committed to be diesel free company.
Bharti Infratel Green Energy & Energy Efficiency Program 'Green Towers P7'	-In 2016,the initiative targeted at 22,000 tower sites for reducing 1.5 lakhs MT of carbon emissions per year (with initiatives such as solar (installed 3 MWT of solar capacity), Energy efficiency systems like Integrated Power Management System (IPMS) , variable speed DC Diesel generators (DCDG) ,replacing air conditioners with Free Cooling Units (FCU) etc) and GenX. -In 2016-2017, converted 43% of its network into green network with more than 3000 solar powered sites and 38,962 green sites. -Through energy savings efforts reduced 3% in diesel consumption per shared site in three years from 2015 to 2017.
American Tower Corporation	-Replaced Diesel generator with captive hybrid solar system installation of 4.4 KWp per site at 450 sites in eastern India, with adding up to 2MWp (Mega watt installed capacity) contributing, on an average, 2,500 MWH (Mega Watt Hour) over a year -Developing a zero-power cooling solution using ambient wind flow for Telecom shelters.
Tata Teleservices	-In seven years initiative, converted 17849 sites from indoor to outdoor and free cooling units used. Annually saving 7207 KL diesel consumption and 68227 Tons of carbon

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

Project Optimus	footprint with this move. -The project's result- since 2010 total saved OpEx of Rs. 9231, 22,800, 63300 megawatt electricity, 7869 KL diesel and massive Co_2 emission reduction. -With initiative, TTL has reported 33 % reduction in its carbon intensity per sub to TRAI in FY 16 -17 (19.16 kg/sub) over the base year of FY 11-12 (28.79 kg/sub). -Six core locations are consumed 12,950 MWH renewable energy from wind energy firms 2017-18 -64,118 kg E-waste disposed in an environment friendly way
GTL Infrastructure	-Reduced power, fuel & maintenance charges by installing free cooling units, deep discharge and quick recharge batteries resulting in substantial savings of US$ 5million over the last 2 years. -Achieved Network cost optimization initiatives savings of US$ 8 million -Total 7,875 'Diesel Free Sites', about 2,926 'Diesel Free Sites' operationalised

6. CONCLUSION & DISCUSSION

It was found in the study that although reduction in Diesel Dependency and its related carbon emissions is a Top priority for all telecom players but since the industry is beleaguered under pressures of dropping revenues and piling debts, the main focus of the hour is more on their survival and improving their bottom-line as high competition has nearly cleared out some big and nearly all the small players from the market. The industry which once contributed about 15% to the GDP is now just contributing nearly more than its half around 6.5% presently. The Green and sustainability strategy took a backseat for a while, as their ambitious plans of going green with Renewable energy have slowed down though site efficiency improvement measures are continuing but at a lesser scale. However, during the period between 2010 and 2016, the Industry players took several remarkable measures that veered towards achieving a Green Telecom policy, and gave impetus to the adoption of environment friendly technology in the industry. Presently, market is moving towards price correction with minimum recharge plans for data consumption, so as the ARPUs will improve, things will turn for better. The reality check is that to grow and expand in the rural areas and to replicate its urban success, the companies must go green with innovative and cost-effective technologies for long term business strategy. The Indian Government's BharatNet-II programme that picked spotlight in 2018 on rural broadband will provide the requisite push, by offering Rs.3600 subsidy to private players for rural broadband expansion. Further, the Rs.500 crores Research and development corpus for 5G technology is another added advantage as the fifth Generation 5G technology is projected to create an impact of 1 trillion US dollars on Indian economy, a necessary short in the arm for the industry.

ISSN: 2455-8834

Volume: 04, Issue: 05 "May 2019"

The period involving 2016 to 2018 was undoubtedly the years of churnings, re-structuring and consolidation for the Indian Telecom sector. The year 2019 and following years markedly will be of innovation, acquisitions, market consolidation and technology disruption. Since, the industry is witnessing a large scale consolidation due to new spectrum trading rules and several mergers & acquisitions resulting in decrease in the number of telecom players. As 4G penetration and 5G & BWA roll-outs increase with network reach across the country, and the telcos launch latest and faster technologies, the future growth scenario for telecom companies seem phenomenally promising. The precondition for augmenting and boosting the telecom sector is progressive sectoral reforms that are achievable with indispensable strong government support and policy framework. As the National Broadband mission, Digital India and Smart Cities initiatives envisages to revolutionize India, the telecom industry is bound to emerge as their key enabler, by providing crucial telecom infrastructure for strengthening digital backbone for pan-India connectivity.

For the 'Go Green' policy to be implemented in true sense, the sector needs to turn the spotlight beyond solar energy, additionally tapping alternative energy options, such as wind, fuels for instance bio-diesel, fuel-cell LNG, CNG etc. The challenge that confronts the industry is high CapEx and a longer term of 4-5 years for Return on Investment (ROI). The RESCO model is still not very popular. At present, the government offers subsidy for renewable energy; however Subsidization is not sustainable over a long period. The government could possibly invest in Public Private Partnership model, to control and lower module market prices and make solar energy economically feasible. The forthcoming fiscal years will be exceptionally challenging for the telecom industry. The principal challenge would be to continue the graph of growth rising, while resolving the existing issues and maintaining heavy investment that is required in building a desirable ecosystem for market dominating newer technologies coupled with carbon emissions mitigation and operating costs reductions. With an objective to achieve an all-encompassing environment centric green momentum in the telecom industry, the industry needs to resolve the challenges in achieving high energy-efficiency in its operations and the government ought to prioritize on the formulation of policies providing requisite support for the production and usage of Green energy in India to achieve its mission 2020 of empowering millions of lives in sustainable and environment friendly way.

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Volume: 04, Issue: 05 "May 2019"

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