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Energy Demand Analysis of Telecom Towers of Nepal with Strategic Scenario Development and Potential Energy cum Cost Saving with Renewable Energy Technology Options

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Abstract: Telecom towers, technically known as BTS (Base Transceiver Stations) are the most energy intensive part of cellular network architecture and contribute up to 60 to 80% of total cellular power consumption and varies in response to the real traffic demand throughout the day and night. But, thelack of grid availability highlightsa potential barrier to telecom industry growth in Nepal. Nepal has approximately 5,222 telecom towers of which about 22% do operate on diesel generators (DGs) while the remaining by grid electricity with some shares of renewable energy technologies (RETs: solar and/or wind). Despite the large carbon imprint, the uncertainty in power availability has compelled telecom operators to use DGs to ensure continuous supply of power for the better network availability, which translates huge operating costs along with adverse environmental impact. So, it becomes an imperative solution for telecom operators to evaluate all alternatives in order to increase network reliability with reduced energy cost. This study report intentionally focus on current energy consumptionof such telecom towers and forecast thefuture energydemand with reference to growing subscriber trend up to 2025 using LEAP (Long Range Energy Alternative Planning System)withBusiness As Usual (BAU) scenario. A clean energy technology (CET) scenario with possible RET options is also developed and compared with base case scenario through some policy mechanics on behalf of environmental benefits and sustainable cellular communication. Furthermore, this study concludes a potential energy cum cost saving with RET adoption with basic cost economics analysis.

Keywords: Energy Demand; Cellular Network Power Consumption; Renewable Energy Technologies; Carbon Footprint; Green Energy for Telecom Towers; LEAP

I. Introduction

Information and communications technology (ICT) usage has grown at an almost exponential rate worldwide. Mobile subscriber base crossed 5 billion mark in July 2010 and expected to cross 8 billion by 2020[14]. Every year, 120,000 new base stations are deployed servicing 400 million new mobile subscribers around the world[1]. With increasing demand for telecom services, the energy consumption has also grown significantly and poses an environment challenge in terms of larger carbonimprint.

About 3% or 600 TWh of the worldwide electrical energy is consumed by ICT sector. It is estimated that energy consumption for ICT sector will grow to 1,700 TWh by 2030 [18].The total global carbon footprint of ICT industryis in the order of 860 million tons of CO_2 which is about 2% of the global emissions. Of this, the contribution from GSM, fixed and communication devices are around 230 million tons of CO_2 or approximately 0.7% of global emissions[7].

A typical cellular network consists of a core network that takes care of switching, base stations providing radio frequency interface and the mobile terminals in order to make voice or data communications and the power consumption is distributed in them with their functionalities. Telecom towers technically known as BTS (Base Transceiver Station) are the most energy intensive part of the cellular network[21]. It is noted that the GSM (Global System for Mobile Communication) energy consumption are considerably higher than the UMTS (Universal Mobile Telecommunication System) technology-as it is expected because of the different mode of operation of the two technologies[16][17].These towers require continuous power supply from 500W to 5000W depending upon the system capacity (older installation consumes more power than new one because of technological advancement). This would mean the consumption of energy between 12 to 120 KWh per day in different cases.

Since, traffic load in mobile communication networks significantly varies during a working or weekend day, the base station power consumption varies accordingly[4]. With the recent spectrum reframing from 900MHz to 1800 MHz and upcoming 3G and 4G rollouts, number of subscribers is expected to grow exponentially. Nepal Telecom (NT) alone has the subscriber growth from 77.5 million in 2069 BS to 107 million in 2071 BS with market share of 44%[18][19]. The scenario is expected to grow further in upcoming days necessitating additional more towers with higher energy demand to ensure better network availability.

The study report ofLorincz J. (2012) investigated the changes in instantaneous power consumption of GSM and UMTSbase stations according to their respective traffic load. The measurement show the existence of a direct relationship between base station traffic load and power consumption and suggested some energy efficient strategies for cellular networks[16].

According to Technical Experts for Renewable Energy Application Group, TERNA. (2007), the average yearly consumption of a BTS is ca. 35,500kWh, considering that in Italy there are about 60,000 BTSs, the total average yearly consumption of the Italian BTS system is ca. 2.1 TWh/year, which is the 0.6% of the whole national electrical consumption. In terms of economic and environmental impact, the data correspond to ca. 300 million euro yearly energy costs and ca. 1.2 Mton of CO_{2eq} emitted in the atmosphere every year[21].

Lubritto C. (2011) in a study revealed the role of mobile communication systems with general national energy framework and plot the best areas of intervention for saving energy and improving the environmental impact. The new transmission algorithms and the use of RE based techniques have been tested[17].

Amanna A. (2010) made a case study report of Namibia to evaluate the use of solar and wind as a feasible cost-effective energy source for a cellular base station. The trial utilized a 6kW wind turbine and 28kW solar panels combined with battery capable of providing 60 hours of operations and monitoring equipment. The system provided an average of 198kW of power/week which was more than 10kWh necessary for acceptable operations. It has been calculated that the return on investment of 3 years that would save approximately 4,850 kg of CO_2 annually compared to a typical electrical grid installation. An addition 649.25kg CO_2 annually could be saved by eliminating the diesel generators[1].

Goel S. (2014) studied the feasibility of using different hybrid systems for the same load demand in two remote locations in southern India. An optimization model of a hybrid renewable system was prepared which simplified the task of evaluating the design of an off-grid/standalone system. After simulating all possible system equipment with their sizes, a list of many possible configurations was suggested on the basis of net present cost [9].

II. Method

LEAP is chosen as a research tool for this study. It is an integrated modeling tool based on bottom up approach, used to track energy consumption, production and resource extraction in all sectors of economy [12]. To this particular study, it takes energy intensity values with activity data of telecom towers in its current account and demonstrate base year (2012) energy consumption and also forecast future energy demand of telecom towers of Nepal up to 2025 (End Year) with strategic scenario development (Figure 1).

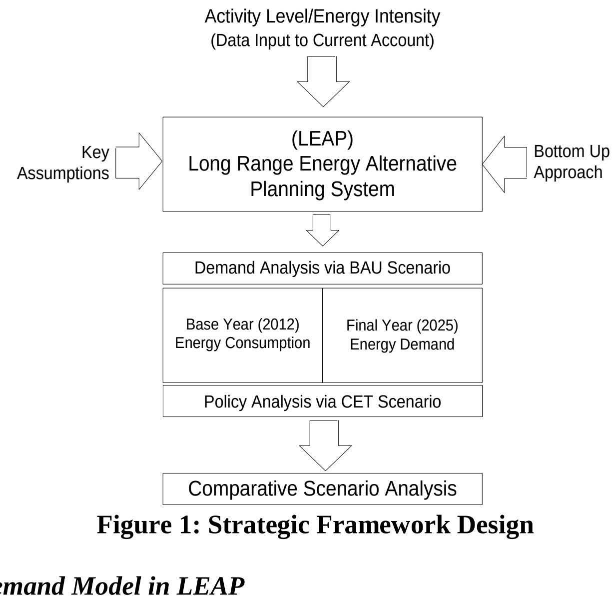

Figure 1: Strategic Framework Design

2.1 Developing Energy Demand Model in LEAP

It is necessary to know, how big is the energy demand of telecom tower before going through any other alternative measures [3][5]. Hence, a strategic measure of energy need oftelecom towers and the growing energy demand are primarily analyzed through LEAP. With reference to the available data corresponding to the base year and other official sources of information [18][19], some sort of assumptions are made to calculate an average energy intensities for different power categories (Table: 1).

Table 1: Average Final Energy Consumption Pattern

Grid Electricity	1.2kW*12hrs/day*330days
Diesel Generator	3liter/hr*6hrs/day*350days
Solar Energy	4kW*5hrs/day*315days
Wind Energy	1kW*6hrs/day*315days

Since, no actual growth rate of telecom towers for each telecom service providers is available, assumption are made in accordance with the annual reports and some contemporary articles [19][22](Table: 2).

Table 2: Growth Scenario of Telecom Towers of Nepal

Growth Scenario of Telecom Towers in Nepal[19]	
Nepal Telecom	Growth(3%)/Year
NCELL	Growth(2%)/Year
UTL	Constant
Others	Growth(0.3%)/Year
Key Assumptions	
National Population	Growth(1.35%)/Year [CBS, 2011]
Telecom Users	Growth(14%)/Year[19]
Telecom Towers	Growth(2.6%)/Year [19]
National GDP	Growth(4.3%)/Year[ES, 2012]

2.2 Energy Demand Analysis with BAU Scenario

With the BAU scenario, base year energy consumption is found to be 341.82 thousand GJ while the end year energy demand is expected to be 630.27 thousand GJ, which is almost double than that of base year energy consumption. This shows that there should have enough energy in order to track the growing energy demand of telecom towers in future years. It seems that NT and NCELL are the major telecom service provider with aggression in market penetration with greater energy demand for future years (Figure: 2).

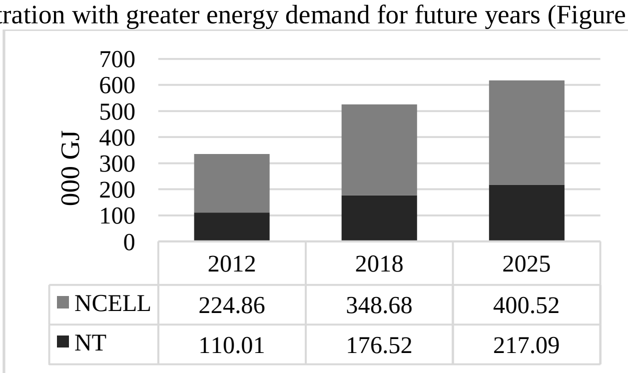

Figure 2: Final Energy Demand (Sectorwise) of Telecom Towers of Nepal with Business As Usual Scenario

Even NT has large number of telecom towers, its final energy demand is lesser than that of NCELL. NCELL has 2051 telecom towers of which 43% are running on DGs whose energy intensity is very large when compared to others energy sources (Figure 3).

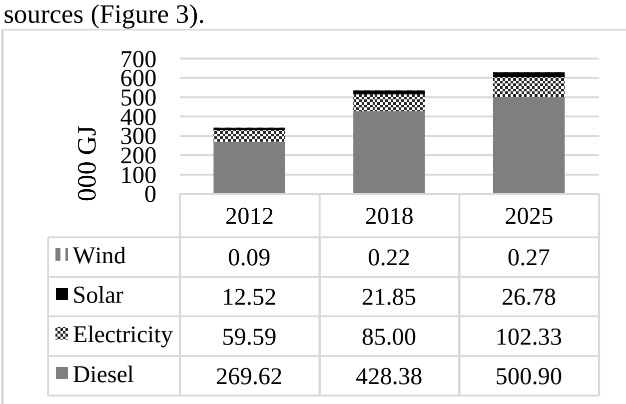

Figure 3: Final Energy Demand (Fuelwise) of Telecom Towers of Nepal with Business As Usual Scenario

NT has some policy initiative regarding the RETs adoption for telecom towers. Most of all, rural CDMA towers are powered with solar PV technology and somewhere in conjunction with wind power technology [18]. NCELL is also moving ahead with “Going Green” scheme and proposed 50% green site in the next two years with solar PV technology [19][22]. Still, the extensive use of DGs by telecom operators in current scenario results in 19.56 thousand metric tons of CO_2 emission at base year which is expected to be 35.54 thousand metric tons to the end year (Figure 4).

It is clear that the future energy demand of telecom towers goes higher with growing subscriber trend. Due to the unreliable power supply and energy deficit of our country these energy demand does not seem to befulfilled accordingly. This definitely necessitates the current energy production systems to add up with RETs for sustainable power supply to telecom service providers. CET scenario deals with all sort of above challenges and provide a strategic policy intervention to power such telecom towers with possible RET options.

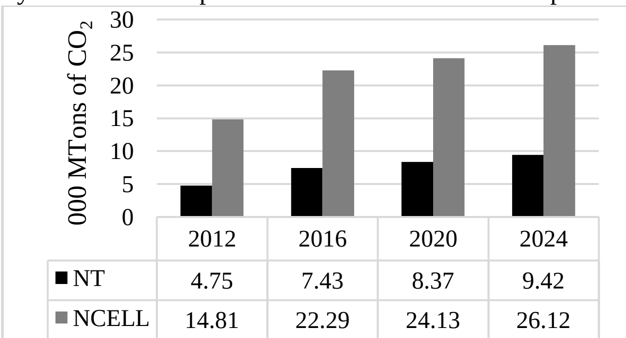

Figure 4: Environmental Effect: CO_2 Emission

2.3 Energy Demand Analysis with CETScenario

The expansion of telecom towers is supposed to be as same as in BAU Scenario (Table 2). Here, some of the additional strategies[8][6][23] are formulated as:

- Reducing 500 liters of diesel per year per telecom tower up to 2020.
- Maintaining an average running of DGs not more than 3 hours a day (i.e. 3150 liters of diesel per year per telecom tower) from 2021 to the end year 2025.
- No additional investment on DGs henceforth.
- Increasing the Solar PV share up to 20% by the end of 2020 and 30% in 2025 for NT and about 12% at the end year for NCELL.
- Increasing the wind power share up to 5% by the end of 2025 for NT and NCELL.

As per the market share of telecom operators and their expansion strategy, UTL has no interest in further expansion of its telecom towers. While Smart Cell and STM totally rely on national grid electricity and NSAT is furthering its telecom towers with 100% solar PV technology[19][22].

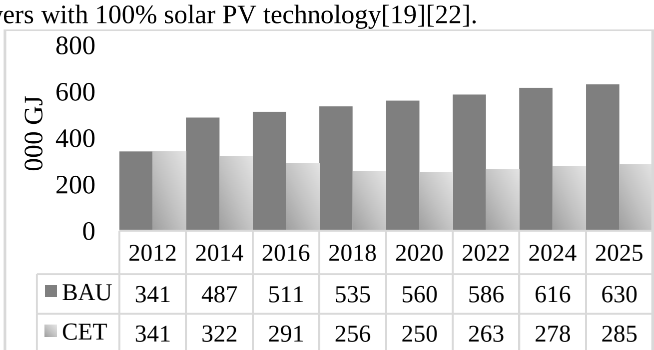

Figure 5: BAU Vs CET in Final Energy Demand

With CET scenario as a policy measure, the final year energy demand is found to be less than a half way to that of BAU scenario in the following years (Figure 5). This is because, diesel is being reduced and RET share is increasing.

While comparing BAU and CET scenarios in terms of 100 years Global Warming Potential (GWP), CET scenario (14.42 thousand Mtons of CO_{2eq}) seems to be very best in reducing carbon emission and maintaining a sustainable environment when compared with BAU scenario (36.45 thousand Mtons of CO_{2eq}) (Figure 6).

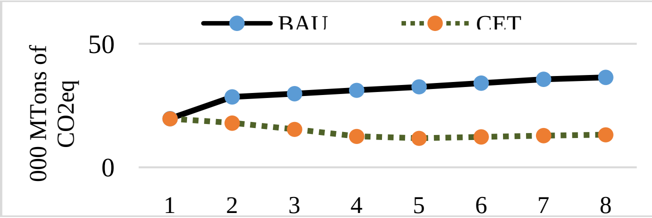

Figure 6: BAU Vs CET in 100 Years GWP

III. A Case Study Review

In the thesis study of author himself [15], the cost economics of RET implementation wasassessed via case study of NT CDMA tower powered by solar-wind-hybrid system located at Dadakharka of Solukhumbu District(Latitude 27°23'50''N & Longitude 86°44'23''E) of Nepal. The model has been optimized using HOMER (Hybrid Optimization Model for Electric Renewables). From the load demand, the net present cost, operating cost/year and the energy cost/kWh were determined [11]. While a comparative analysis has been done between RET powered system and DG powered system through sensitivity analysis in terms of their cost of energy production and greenhouse gas (GHG) emissions.

The study has been done for various telecom loads for scaled annual average solar insolation, wind speed and temperature profile of 5.75 kWh/m^2/day, 5.01 m/s and 11.4^{O}C respectively with diesel price $1.1/liter (Table 3).

Table 3: Comparative Analysis of Different System

Model	Parameters	Load (kWh/day)		
		12	14	16
Solar-Wind-Battery System	COE ($/kWh)	0.349	0.326	0.285
	Total NPC ($)	11,403	12,433	12,433
	Op.Cost ($/yr.)	423	423	423
	Excess Electr^y (kWh/yr.)	2,556	3,902	3,086
Solar-Battery System	COE ($/kWh)	0.314	0.27	0.259
	Total NPC ($)	10,285	10,285	11,315
	Op.Cost ($/yr.)	343	343	343
	Excess Electr^y (kWh/yr.)	3,689	2,865	4,199
DG-Battery System	COE ($/kWh)	3.812	3.282	2.893
	Total NPC ($)	142,142	142,795	143,815
	Op.Cost ($/yr.)	15,052	15,128	15,248
	Excess Electr^y (kWh/yr.)	1480	809	295

From the result, RET powered system could be the best option with total NPC: $12,433/year even it has large investment cost when compared to DG powered system with total NPC: $142,795/year. For an optimal run of atypical tower with 670W peak load powered by DG system, it is found that the system consume 7,120 liters of diesel/year. This revealed the fact that annually about 8 million liters of diesel is being consumed to run such telecom towers in Nepal producing 18,750 kg of CO_2 per year per telecom towers.

IV. Power Outage, Traffic Loss & Revenue Statistics

Out of 5,222 telecom towers of Nepal about 67% towers do operate on grid electricity followed by 22% with DGs (Figure 7). With thousands of BTS installed all over the country, average energy consumption of these towers is moving from huge to humongous. But, the power outage from 4 to 14 hours or even about 18 hours a day as in the worst case of 2009AD (NEA, 2012) is a big problem translating a huge revenue loss/year for telecom operators.

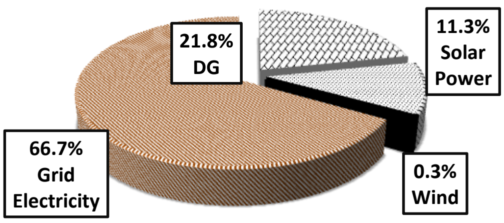

Figure 7: Power Source of Telecom Towers in Nepal

As per (NT, 2013) report [18], in source wise revenue composition of NT, international trunk and local call contribute about 32% and 25% respectively (Figure 8).

On particular concern, according to (MIS Report, 2014) of the company [18][19], NT has 12.87% growth in outgoing calls to foreign destination in January 2014 compared to the same month last year. A total of 15.25 million calls (42.03 million minutes) were made during January 2014 compared to 13.51 million calls (35.81 million minutes) in January 2013. With an average charging of NRs 3.75/minute, NT generates a revenue of 158 million NPR assuming 100% network availability.

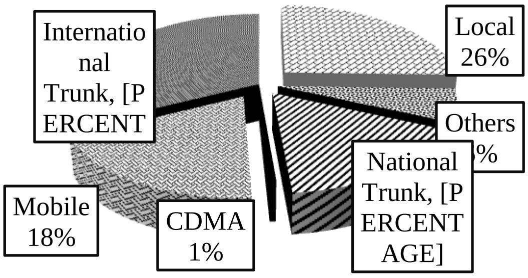

Figure8: Source wise Revenue Composition of NT

If we considered an average power outage of 8 hours/day with no backup power regulation, NT alone incur a loss of its revenue about ca. 53 million NPR/month. Whichtranslates a total traffic loss of ca. 5 million calls/month (if a calling subscriber has an average hold time of 3 minutes). This revealed that about 7000 subscribers are directly affected/hour due to such power outage problem.

On the other hand, an attempted to analyze a revenue statistics with CDMA system described in Table 4. If the charge/minute is NPR 1.8, NT generates a revenue of 60.44 million NPR/year per telecom tower (neglecting all other handover of call to adjacent channels). Since, NT has 586 CDMA base station towers currently in operation [22] hence, the total revenue is about 35420 million NPR/year. Again, if we consider an average power outage of 8 hours a day, NT will have a loss of revenue about 32 million NPR/year that means, about 11.2 million users will be affected directly with 370 thousand hours of traffic loss per annum if a subscriber has average holding period of 2 minute.

Table 4: Local Call Statistics with CDMA System

System Type	CDMA BTS
Model	ZTE EVDO1X 2C10
Carrier Support	2
Number of User/Carrier	35 (Full Load)
Total User/Minute	(33+31) = 64

So, it is indeed, a necessity to recover such a huge loss of revenue for telecom operators. Maximizing the utilization of RETs, the telecom sector could provide a better network availability and thus could make a good revenue collection. On the other hand, this revenue could contribute to national GDP increment and of course for the economic growth of our country [20].

V. Potential Energy cum Cost Savings

As per the LEAP result, CET scenario is found to be strategically good enough to reduce energy consumption with RET implementationin contrast with BAU scenario. Table 5 shows a summary of potential energy saving and corresponding save in cost of energy after CET scenario implementation. To generalize the cost estimation, the cost per unit of electricity consumption is assumed to be NRs. 9/kWh. It is found that, 9.6×10^7 kWh of electricity at the end year could be saved which corresponds a cost saving of 861 million NPR.

In the case of Pakistan [10], where Telenor telecom operator is the one, which has more than 7000 sites operational all over the country. Pakistan is also facing an average 6-8 hours of load shedding each day. Each of the BTS station takes an average of 3-4kWh of total load hence, 21MW of electricity if being consumed per telecom operator/hour. This means 378MW of electricity is being consumed each day by one telecom operator. On the other side, DG used as a backup for BTS towers runs an average of around 4-6 hours each day. If only 30% of this grid electricity consumption can be saved by installing RETs like solar or wind, Pakistan can save around 110MW/day of electricity just from one telecom operator which will translates a total saving of 500MW of electricity per day.

Table 5: Potential Energy cum Cost Savings

Energy Demand					Potential Energy/Cost Saving	
Scenario	**BAU**		**CET**			
Year	**$x10^7$ kWh**	**$x10^7$ NPR**	**$x10^7$ kWh**	**$x10^7$ NPR**	**$x10^7$ kWh**	**$x10^7$ NPR**
2012	9.5	85.5	9.50	85.46	0.0	0.0
2014	13.53	121.8	8.94	80.46	4.6	41.3
2016	14.21	127.9	8.10	72.90	6.1	55.0
2018	14.87	133.8	7.12	64.08	7.8	69.8
2020	15.56	140.0	6.97	62.73	8.6	77.3
2022	16.28	146.5	7.31	65.79	9.0	80.7
2024	17.11	153.9	7.73	69.57	9.4	84.4
2025	17.5	157.5	7.93	71.37	9.6	86.1

In Nepal, if we can contribute current energy demand of telecom towers with 40% renewable energy share (as proposed in CET scenario) like solar and/or wind, 96000 MWh of electricity could be saved per year. So why not to proceed through clean energy implementation in powering such telecom towers.

VI. Conclusion

In this work LEAP is used as one of the research tool to analyze the base year (2012) energy consumption of telecom towers of Nepal from the best available data. The model is also developed to analyze the energy demand up to 2025 (end year) with 'Business As Usual' scenario. The base year energy consumption is found to be 341.82 thousand GJ which is expected to grow up to 630.27 thousand GJ at the end year. Out of 5,222 telecom towers of Nepal about 22% towers do operates on DGs with corresponding energy consumption of 269.62 thousand GJ in 2012. Whereas, for the same year, 19.56 thousand metric tons of CO_2 emission is calculated and if this continued it is expected to be 35.34 thousand of metric tons of CO_2 emission at the end year.

The methodology has been also developed for carrying out a policy mechanicsthrough Clean Energy Technology (CET) scenario. The assumption are made with existing market expansion in response to growing subscriber trend. With RET adoption in powering telecom towers, the energy consumption is found to be minimum in scenario years when compared with BAU scenario. The end year energy demand is found to be 285.48 thousand GJ. The corresponding carbon emission in CET scenario is also decreasing and found minimum with growing energy demand exactly half a way than in BAU scenario. Moreover, CET scenario has shown a clear significance with less GWP with value 13,110 Mtons of CO_{2eq} when compared to BAU scenario with 36,459 Mtons of CO_{2eq} emission during the end year.

With a case study, the cost economics of different system is analyzed by defining the cost function in terms of reliability and cost of energy (COE). From the analysis, DG system requires huge operating cost ($15,128/year) with COE $3.282/kWh, while solar-wind hybrid system has an operating cost: $430/year with COE $0.321/kWh. Hence, increasing renewable energy share against convention fuel could be a great deal to power such telecom towers both economically and environmentally.It is found that, up to 2025, $9.6x10^7$ kWh of electricity could be saved which corresponds a cost saving of 861million NPR withrenewable energy implementation. Similarly, 20.02 thousand Mtons of CO_{2eq} emission could be reduced up to the end year with CET scenario. Hence, RETis therefore, a clean, energy efficient and a sustainable way of powering such telecom towers.

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