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Massive Energy Saving Systems and Strategies at Equipment Level in the Highest Competitive Telecommunication Market

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Abstract
Reducing operational expenditures (OpEx) have become main concern for almost all communication service providers in the world. Some practical ideas and techniques implemented in Grameenphone might be very helpful for others who are fighting to survive or trying to be more profitable or going to provide new services-3G /LTE/LTE-Aor want to contribute in climate change anywhere in the world. Some challenging techniques and tactics are discussed here to reduce vast amount of energy consumptions from different equipment used in the base station, access and transport network for cost reduction.

Index Terms- OpEx,BS, RAN, TX, AC, DC, microwave, transport, Power, DC ventilation, DVS, Battery, VDTC, ESC, QoS, KPI

I. Introduction

Grameen phone (GP) Ltd. (a sister concern of Telenor) is the leading and largest telecommunication service provider in Bangladesh since its inception in 1997 with more than 50 million subscribers right now. The massive challenges and dynamic changes happened in the last few years in this company forhuge increased expenditures (OpEx / CapEx), large traffic growth,cumbersome legislations and more competitors in the market.Some important techniques and strategies are implemented with highest priority in the power, radio and transmission sectors to reduce cost, increase RAN/TXcapacity for subscriber growth, overcome regulations, provide 3G/HSPA+/LTE service as well as sustainability.[1][2]

II. Energy Saving Techniques

After a decade of successful operation, every companies in the market of Bangladesh (total six operators) faced fierce competitions: some sold their shares, some packed up their business. GP also lost their market share from over 55% to less than 42% but was able to hold the leading position, profitability through substantial changes in the entire network infrastructures, technologiesas well as strategies.[3][4][5]

2.1 Cooling System:

Standard temperature inside the base station (BS) room is very much important for the optimum network quality and performance, cell coverage, equipment fault rate etc. Earlier, air-conditioners running on commercial **AC** power were used in sites to maintain the standard room temperature. Ventilation fan system running on **DC** power was a new concept to save electricity consumption by reducing the operating hours of air-conditioners or replacing them in on-aired sites. The frequent load shedding, low voltage and long time power outages made the power situation vulnerable and as a result, higher equipment fault rate including air-cooler, poor QoS, reduced capacity/coverage, fire incident. Also the price of the electricity was high and rose gradually, Grameenphone had to pay more than 22,000 BDT per site before the project. Grameenphone had about 8000 base stations countrywide and savings from air-conditioners contributed a huge OpEx.Grameenphone operated in a highly competitive market and was pursuing cost optimization. Grameenphone was also trying to reduce CO_2 emission to put significant contribution to climate change through reducing energy consumption or using green technologies in its sites.The logic matrix was set at controller of DC ventilation system (DVS) to

Input's definition

T_L	**Lower threshold for room temperature**	
	T_L = 1	When inside room temperature <= set value for Tl
	TL = 0	When room temperature > set value for Tl
T_H	**Higher threshold for room temperature**	
	Th = 1	When inside room temperature => set value for Th
	Th = 0	When room temperature < set value for Th
T_O	**Outside environmental temperature**	
	To = 1	When outside temperature < inside room temperature and set threshold value
	To = 0	When outside temperature > inside room temperature and set threshold value

Logic chart

Input			Output	
T_L	To	T_H	DC Fan	AC Run
0	0	0	0	0
0	0	1	0	1
0	1	0	1	0
0	1	1	1	0
1	0	0	0	0
1	0	1	X	X
1	1	0	1	0
1	1	1	X	X

Fig.1:Logic Matrix for the DVS

operate DVS and air conditioner in the base station.[6]

AC will run when:

- Inside room temperature is higher than the set higher threshold.
- Outside temperature is higher than inside room temperature.

Fan will run when:

- Outside temperature is less than inside temperature and set threshold value.

The operating voltage of DVS was 40 to 60V DC and consumed approx. 200watt power.[7][8]

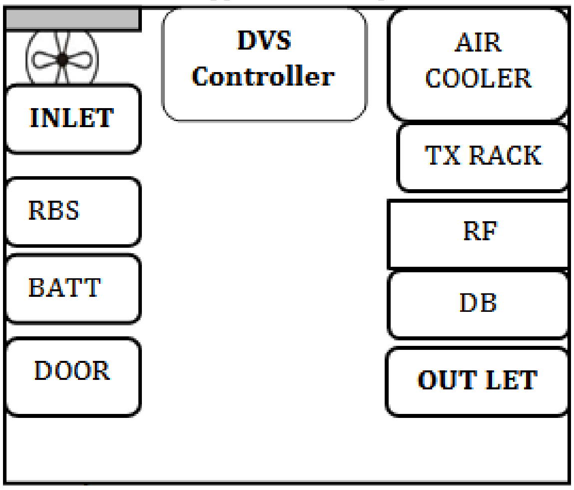

Fig .2: A typical diagram of DC Ventilation System in BS

SITE	1-Jun	9-Jun	21-Jun	7-Jul
ENERGY METER READING DURING INSPECTION	191978 KWH	192399 KWH	193125 KWH	195002 KWH
DATA ANALYSIS				
ENERGY CONSUMED	1147 KWH		1877 KWH	
REDUCTION OF ENERGY CONSUMPTION WITH RESPECT TO 20 DAYS TEST DATA FOR BOTH INDIVITUAL CASES	730 KWH			
TEST RESULT				
PERCENTAGE OF ENERGY SAVING	38.90%			

Table-1: A typical data of energy saving

The savings from electricity per site was more than 8,000 BDT per month (average bill before= 19,150BDT and average bill after=10,750BDT: almost 40% cost saving) whereas the investment was around 25,000 BDT (DVS could provide return just after three months). For nice performance of DVS, air-conditioners were removed from almost all base stations and hub sites were also running based on DVS where air conditioners remained standby for backup. As a result, more than **50%** cost reduced for energy saving from DVS while operating alone for cooling BS. This figure jumped a bit high to **55%** when transmission hub sites' cooling system came under DVS system. Some other key results identified after installation of DVS.

- Air conditioners and DVS performed as per logic matrix.
- The performance of DVS was good and no critical faults in this test periods.
- The quality KPIs of RAN were good.
- The performance of TX link was not hampered.
- The battery backup reduced due to additional load & this impact was very nominal.
- The dust and noise problem minimized by replacing with filter of better quality,concealing the other cable holes and regular servicing.
- Due to functioning of DVS in absence of power unavailable, temperature was stable and external alarms reduced.
- The fault rate of air conditioners was reduced as it had time to remain switched off.

  Further research and testing required for accurate measurement of KPIs related improvement and impact for temperature.

2.2Control Devices:

2.2a: Energy Saving Controller (ESC):

The energy bill per BS was very high and increasing day by day due to raise of traffic per base station (BTS) and tariff rate by government.It had been an urgent issue to curb the operational expenditure (OpEx) to sustain in the highly competitive market of South East Asia. The idea was to shutdown power consumption during peak hours (5.00pm to 11.00pm) due to peak tariff rate is much higher than that of off-peak. In off peak time, commercial electricity would be used to charge battery and storage energy would be used to operate base station in peak time.

ESC is a very simple low cost device consist of a clock and timer. The commercial three phase power would go through a magnetic contractor regulated by this electronic circuit and used between main circuit breaker of DB and bus bar from where load are distributed. The energy saving control (ESC) system would be installed in city areas where double tariff rate exists. ESC contributes in the following ways:

¬ Substantial contribution to severe national energy crisis mitigation.
¬ Reduce energy cost by consuming off-peak tariff rather than peak.
¬ Contribute to green globe by reducing energy consumption.
¬ Reduce fault rate of air-conditioners

The battery backup initially reduced slightly due to higher room temperature for long time (maximum 6 hours) and this problem was solved later by incorporating high temperature alarm with battery disconnected pre-alarm after consulting with managements. Before ESC installation, the fault rate of air-conditioner was high as it run for 24 hours. But after ESC set up, the frequency of fault reduced remarkably because everyday air conditioner could take rest for 4-6 hours. After data analysis, network quality KPIs were found not hampered for ESC.
The savings from energy consumption per site was more than 3,500 BDT per month (average bill before was about 25,000BDT and average bill after became around 21,500BDT: almost 15% savings) whereas the investment for ESC was around 10,000 BDT.

2.2b: Voltage Dependent Timer Circuit

Specifications of voltage dependent timer circuit (VDTC) for single Generator
Sequence of triggering (Battery backup-Generator – battery backup):

1. The timer circuit should be dependent on battery disconnected pre alarm of rectifier.
2. This timer will allow the system to run as per the following sequence after the mains off condition
a. Generator will not run until and unless the BTS system voltage goes on certain voltage level as per user define (45 V – 49 V DC)
b. After that generator will run from 2 hours to 6 hours as per user set time
c. The same of a. again
d. This a,b,c sequence will be continued till the mains come (Optional feature for future use, if required)
e. There should be temperature sensing option which can read the user defined extreme value of BTS temperature from the BTS temperature sensor and then it will reset every thing and follow up the sequence band then continue the same.
3. The alarm sensor should be compact in size.
4. The timer circuit should have a bypass switch to bypass the circuit in case of any fault in the device. If the additional kit is faulty then the generator can be triggered by the previous timer (only single cable physical connection is required to make)
5. Visualization display regarding the time counting and as well as the indication of LED should be available for easy understandable of the sequence
6. All the necessary marking should be screenprinted properly on the timer
7. The timer should be installed in the Generator room.

VDTC can be operated based on signal input from both temperature and battery voltage level of BTS room. It’s called real time VDTC (RVDTC). The battery voltage and temperature of the BTS room can be seen into the LCD display of the VDTC. As voltage & temperature setting is different for different brand rectifier, connection would be also different.Voltage level setting range: 40v DC to 60v DCor 18v DC to 30v DC. BTS room temperature setting rang: 15° C to 50º C.

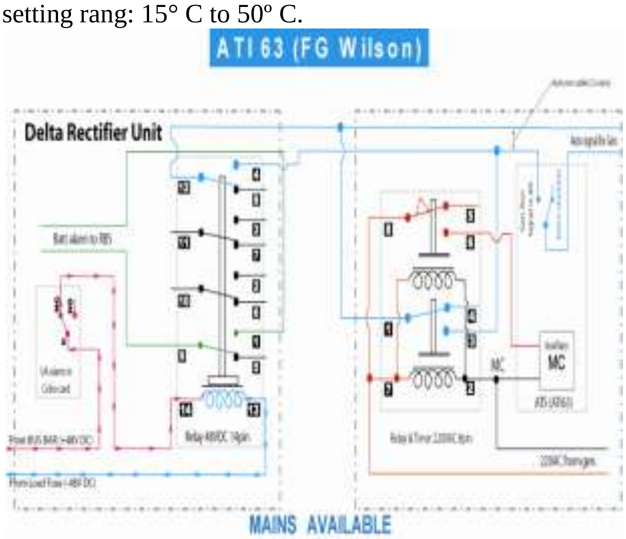

Fig.3: total connection diagram of RVDTC

VDTC controls the running hour of the generator having monitored ATS. Before VDTC setup, Generator run immediately just after commercial power out. VDTC makes generator start delay until a certain voltage/temp level and thus saving fuel cost. It could save around 30% run-hour of generators and might reduce substantialoperational expenditures (OpEx), fault rate of generator or other BTS room equipment as well as contribute to national energy crisis and climate change.
Fig2.2b: Cost Saving from VDTC

Total BTS Fuel cost for a year in Millions (BDT)	232
Total Running hour savings in %	30%
In absence of VDTC the Total fuel cost would be (TK. Million)	317.08
Net Savings due to integration of VDTC (BDT. Million)	85.80

Table-2: Cost saving

2.3Renewable Energy (Solar Power):

Solar power is the most popular renewable energy. Solar panels generate DC power of different voltage ranges. Power generation from solar panels depends on the availability of sun and angle of incidence of sunlight on the panels. As per GP's specification, the installed panels of these systems generate 34 to 36 Volt DC power.The power generation from each panel is of lower range [34-36 V, which is not hazardous for human body], but the output from an array [multiple panels connected in series] becomes higher than the safe range of 120 V DC.So it is needed to take proper safety precaution while handling array structure.

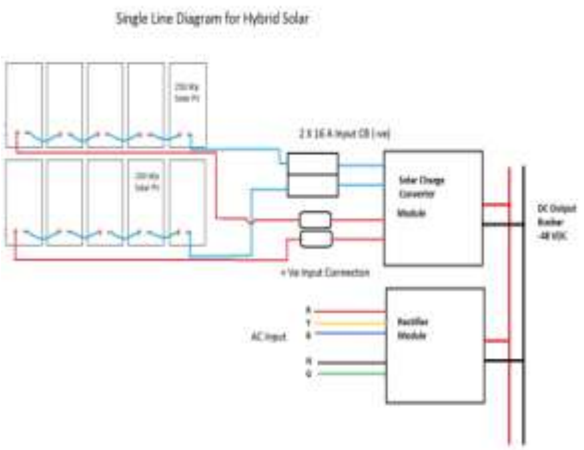

Fig .4: Single line diagram for Hybrid solar

All data regarding energy is available in Smart Pac controller(whenboth controller of solar control panel and rectifier is Eltek brand). Energy generation from solar panels with respect to different time period [Hourly/daily/weekly] is also available, from which we can measure the output. As an example,power usage and generation from 2.5KWp solar system in a rural base station site is as in the following:

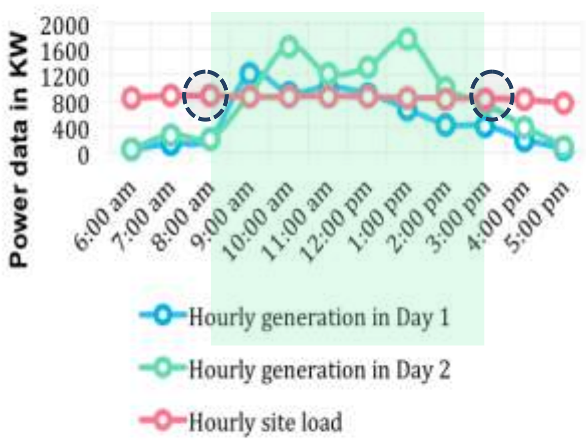

Fig.5: Solar power generation and usage

- Average daily generation is 9 KW from 15 days of operation.
- In best cases this BTS site will run with Solar generated power only for 6 hours (average 20% saving)
- From installed capacity and geographical location we can get maximum 11.25 KW generation in best case.
- In this site 11 KW has been generated in a day.

If the generated power from solar system is higher than site load remaining power will be used to charge the battery.

If the generated power is less than site load additional power will be used from battery storage.

The operational or maintenance cost for solar power system is very little. In most situations cleaning is only necessary during long dry periods when there is no rain to provide natural cleaning. To remove a layer of dust and dirt from the modules (panels), simply wash the panel with water. If the module has thick dirt or grime, which is harder to remove, wash with warm water and a sponge.No detergent or power is allowed to use to clean panel. Sometimes, it's needed to check physical damage,chips or discoloration on solar panel /module /cabling and structure.

The purchase cost is the main expenditure to have solar power system. Installation cost is normally included with purchase package. Whereas governments of almost every countries provide huge rebate on solar system and it gives long time service at nominal cost. It is also very friendly for green environment and sustainable output in the highly competitive market.Solar power was considered for power source where commercial electricity was not available in past but it's benefits overcome the barrier and now widely used in rural and urban area, in parallel with other sources.

2.4Resources Optimization:

Grameenphone saves huge amount of money by e-using or re-locating radio, transport or power esources.It has own lab to test equipment returned y field engineers, before sending to vendor, ometimes they are repairing some items and saving uge money. Field technicians are also re-locating esources from one site to another for capacity up radation, fault handling or service up gradation. he cost of manpower in South East Asia is very low ut price of new equipment or vendor repairing is igh. I think all operators from this region could take hese great advantages. However research on energy fficient technologies contributed less power-onsumedequipment and up gradating RAN and TX etwork for HSPA+/LTE also kept a pretty good nergy saving to OpEx.

2.5Energy Management:

Grameenphone is working from every single corner to reduce operating cost. There were some wonderful scopes with energy meter to workout. There are different tariff rate for different time (5pm to 11pm: peak time, rest time: off-peak). Digital energy meter can show separate reading for peak time. Operation can install control device to cut commercial power at peak time whereas analog meter wouldn't give this benefit. We have set threshold for each category of base stations after calculating total loads, analyzed energy bill to find discrepancies. We have changed analogy meter by digital to gain peak hour benefit, made easy to access meter for reader, manage authority (DESCO, DPDC, REB) to correct wrong high bill- may be for faulty meter, display problems, disconnect unauthorized power connection from our lines, claim rebate etc. This ways we have saved about 12 million BDT in 2013, more than 5% in the whole attempt of energy savings.

III. Conclusion

Energy scarcity for telecommunication market is increasing day by day as more infrastructure deployment to cater the rising number of subscribers, usage and applications around the world. The continuous increment of energy consumption is a big threat of run out and climate change. Telecommunication sectors can also reduce energy consumption at massive volume from replacing or controlling cooling system, generator run, commercial power consumption, installing solar power system, upgrading radio and transport devices, changing infrastructures. Government increased tariff rate by more than two fold. After implementing all the above strategies, still GP pay less than the previous amount – a big volume of energy saving (grossly more than **100%**per site, after increment of energy unit rate more than two fold) from around 8000 BTS definitely would make any operator profitable and capable to sustain in any competitive market.

Saving Lead	Approx. %
Cooling System	55
ESC	15
VDTC	10
Solar Power	20
Resource Optimization	5
Energy Management	5

Table-3: Net Saving by GP

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