

Defense & Technology Paper

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A Process to Analyze Data from the Deployable Metering and Monitoring System Using United Nations Interim Force in Lebanon Data, with Recommendations from a Limited Dataset

Julie Sapp, Paige Rudin, Abby Lemert, and Michele Gardner



CENTER FOR TECHNOLOGY AND NATIONAL SECURITY POLICY

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Acknowledgments

We were pleased to be able to contribute to the effort by National Defense University, in collaboration with the United States Africa Command J804, US Army Construction and Engineering Research Laboratory (CERL), and United Nations Peacekeeping Operations (UNPKO).

We thank UNIFIL site members for providing data, and the Electrical Team at UNIFIL specifically for their willingness to answer data-related questions.

We especially thank Tom Decker and Rich Weichsler from the United States Army Corps of Engineers, for their technical expertise and assistance in prioritizing and explaining the various types of analyses that could be conducted on the UNIFIL data.

Executive Summary

The United Nations Department of Peace Keeping Operations (UNPKO) leads and supports the efforts of the United Nations Interim Force in Lebanon (UNIFIL) to maintain peace and provide humanitarian aid. With over 50 camps located in the country of Lebanon, the UNPKO is striving for energy efficiency to ensure day-to-day operations are using resources effectively. In 2017, the U.S. Department of Defense (DoD) conducted a study¹ rooted in the UNPKO mission to maintain energy efficient camps by analyzing data from metering systems to develop technology insertion recommendations.

The beginning steps of the DoD study involved receiving deployable metering and monitoring systems (DMMS) data sampled from six UNIFIL sites. Although DMMS refers to a larger, three-pillared approach to data gathering, and the data here represents only a portion of one pillar, the DMMS acronym is used to reference the UNIFIL data in this study. Five analyses were designed to draw useful conclusions from the data for UNPKO staff located on-site. The five-step analysis process included: *Analytic 1*: Time Period of Fluke Data Collection vs. LOG Data Collection, *Analytic 2*: Determination of Partial or Complete Load Breakdown, *Analytic 3*: Determination of Appropriate Generator Number, *Analytic 4*: Comparison of Phase Balancing, and *Analytic 5*: Analysis of Daily Load Curves. The methods for conducting the analyses are detailed in this report to enable similar analyses of future UNPKO DMMS data sets.

The analyses were used to produce a set of recommendations on generator use specific to the UNIFIL camps included in the data. After conducting the five initial analyses, additional analyses were designed that could be employed in future studies of UNPKO DMMS data sets to reveal new trends and insights. One example, which entails correlating the DMMS data with external factors affecting energy consumption, is explored in detail. General trends across all UNIFIL DMMS data sets are identified.

It was generally found that UNIFIL camps had generator capacities which far exceeded peak daily demands. The recommendations in this study could be used to determine appropriately-sized generators and develop schedules for usage. Actions could be taken across UNIFIL based on these recommendations to lower costs by eliminating unused generators.

1 UNPKO Pilot 2 Program

Background Information

UNIFIL was established 19 March 1978 and as of 2017 contains 11,317 personnel, both uniformed and civilian, from 40 different countries¹. The primary goals are to ensure peace and provide humanitarian aid for the Lebanese people in the midst of existing geopolitical tensions. The on-site amenities range from kitchens to hospitals to workshops, varying according to the needs of a specific local area.

The need to provide efficient, sustainable facilities and services to those at the camps is fundamental for future operations. Progressing towards more innovative practices and increasing energy efficiency is a primary goal of the UNPKO, which leads and supports UNIFIL. To assist in those goals and desired innovations, the UNPKO Pilot 2 Program was created. The Pilot 2 Program consists of a preparation and execution of site assessments and implementation of deployable metering and monitoring systems (DMMS); holistic data collection, research, and analysis to inform technology insertion recommendations; preparation and execution of technology insertion, demonstration, assessment, sustainment, and transition plans; and development of a final publication. The program plan has been conducted in coordination with USAFRICOM J804, US Army Construction and Engineering Research Laboratory (CERL), and National Defense University Center for Technology and National Security Policy.

This report, in support of the Pilot 2 Program, consists of an analysis of DMMS data on power supply and consumption collected from a sampling of camps within UNIFIL from late 2016 to early 2017. This analysis fulfilled several specific tasks and objectives from the Pilot 2 Program. Tasks 3.3 and 3.3.1 led the analysis process and created a basis structure to support the additional tasks listed below. These include:

Task 2.1.3. Develop site assessment methodology, data collection template(s), cost and schedule, expected outcomes, metering and monitoring insertion requirements, areas of responsibility, equipment and training required, logistics, sustainment, etc. in coordination with UN.

Task 2.2.2. Collect and categorize site assessment data for use in technology recommendations.

Task 3.1. Historical analysis of Contingent-Owned Equipment (COE) reimbursement structures for power supply and demand, water and wastewater, and solid waste management equipment, based on information gained from participation in COE Workshop of January, 2017.

Task 3.3. Historical data analysis at United Nations Interim Force in Lebanon (UNIFIL).

Task 3.3.1. Collect, categorize, analyze, and visualize existing metering and monitoring data and produce visual overlay for use in technology recommendations.

Analysis Overview

To complete a detailed analysis of DMMS data across camps, it was necessary to develop and define a standardized process for interpreting trends in the data because data collection methods and spreadsheet formats varied significantly. Raw DMMS data provided by UNIFIL was used exclusively in the analyses. The analytic process was broken into five distinct but interdependent components represented in Figure 1. Each subroutine represents a single analytic and enabled specific recommendations to be made with the purpose of increasing energy efficiency. Creating efficiencies will improve cost savings and reduce environmental impact.

Patterns were sought to determine where and when generators were unbalanced or sized for peak rather than average energy loads and could be downsized, turned off, or used elsewhere during non-peak times.

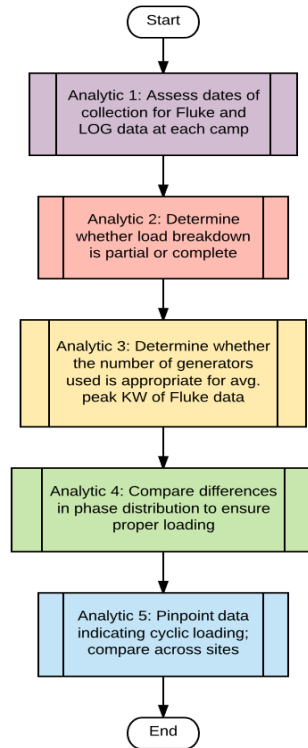


Figure 1: High-level flowchart of DMMS analysis process

Analytic 1 compares the time period of data collection for power supplied by generators across an entire camp (Fluke data) to the time period of data collection for power consumed in specific camp divisions (LOG data) to determine if data is missing from either set. Concurrently, Analytic 2 sums energy consumption data from all camp divisions (LOG) at a given time and compares it to the energy supplied (Fluke) at the same time. If energy consumed is not equal to energy supplied, the load breakdown is incomplete, meaning that not all energy used in the camp is reflected in LOG data sheets. If Analytics 1 and 2 reveal missing information, the camp should be contacted to request the complete data set to ensure the most comprehensive and accurate analysis possible.

Next, Analytic 3 plots all power supply data to determine the maximum value over the camp's collection period. Generator ratings are summed to compare the camp's capacity for energy creation to what is actually produced; some generators may be turned off permanently if a limited number is sufficient to meet the maximum production need. For a generator to operate efficiently, its power should be distributed evenly across three phases of energy--Analytic 4 compares phases to ensure that no two have a difference greater than 20 percent, indicating an unbalanced load and avoidable expense if the load was redistributed. Finally, Analytic 5 categorizes divisions within a camp according to their reported purpose (i.e., living quarters, ablutions, kitchen, etc.) and identifies daily cyclic trends to recommend the disuse or reduced capacity of a generator during periods of decreased load.

While most analytics can be completed separately or concurrently, there are some key interdependencies affecting analysis progression. Analytics 1 and 2 must be complete before progressing to 3, 4, and 5 because missing data may significantly impact any conclusions or recommendations drawn from these steps. Analytics 3 and 5 should be compared and their recommendations consolidated because they both relate to generator number and capacity. A low-level logic flow of the entire analysis procedure is mapped by Figure 2. Appendix Figures B1-B3 provide a closer look at individual segments of the process.

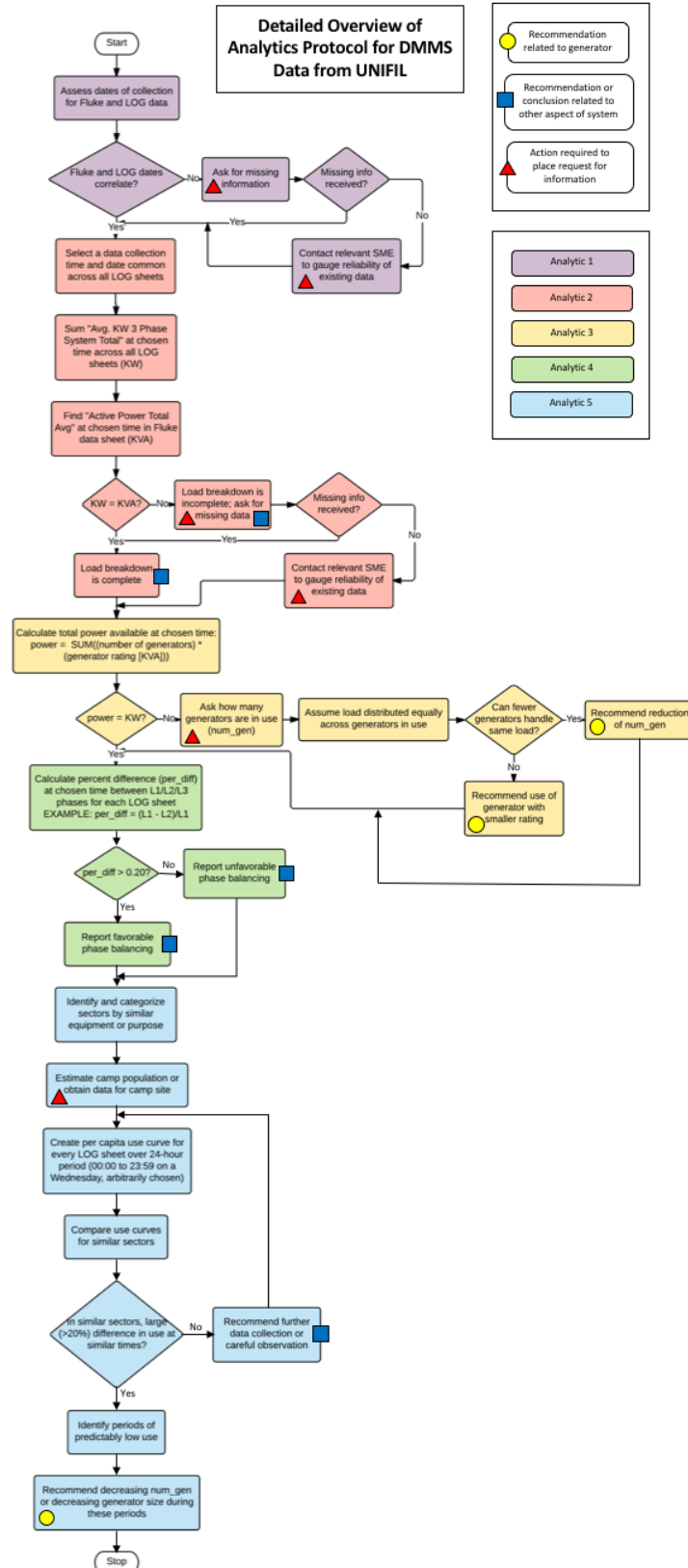


Figure 2: Detailed logic flow of Analytics 1-5 for DMMS analysis

Camps 1-0A, 5-10, 5-66, 7-1, 7-3, and 8-30 are examined in this document, but the process and recommendations are intended to be transferrable to any camp that may wish to install a DMMS to monitor its energy usage. For analysis of these camps, it was assumed that, unless otherwise stated, generators consume diesel fuel at a constant rate for all periods of energy generation.

Analytic 1: Time Period of Fluke Data Collection vs. LOG Data Collection

Rationale:

Fluke data measures the amount of power supplied to all sectors of the camp by generators over a certain period of time. Meanwhile, LOG data represents power consumption of a particular sector of the camp over potentially different periods of time. In order to produce the most meaningful analyses of camp efficiency, Fluke data (supply) should be compared against LOG data (demand). However, those comparisons require that data for both Fluke and LOG are collected simultaneously. Therefore, the initial analysis must determine for what periods of time data exists for both Fluke and the various LOGs.

Methods:

For each camp, the start and end times of Fluke data collection were recorded. Additionally, the start and end times of LOG data collection were recorded. The start times of all data sets were then compared to the end times of all data sets to determine gaps in Fluke or LOG data collection. The missing time periods of data were then requested.

Results:

Presented below is the example of the results for the Sector West 5-66 camp. Collection start or end times that differ significantly from the other data sets from the camp are highlighted in yellow. Full results for other camps can be found in Appendix A1.

SECTOR WEST 5-66

	Collection Start	Collection End
Fluke	1/19/2017 09:19	1/19/2017 13:19
LOG 111	1/19/2017 09:30	1/25/2017 09:00
LOG 112	1/19/2017 10:00	1/25/2017 09:20
LOG 113	1/19/2017 09:30	1/25/2017 08:50
LOG 114	1/19/2017 09:50	1/25/2017 09:10

Comments: Fluke data lasts only 4 hours, LOG data was recorded over 6 days. Same start time for all data sets. All necessary column categories are provided.

Conclusions:

In one camp, the Fluke data set and all LOG data sets generally corresponded in start and end collection times. In two camps, Fluke data is missing for a significant period of time. In two camps, one of the LOG data sets is missing for a significant period of time. In one camp, Fluke data is missing altogether, though LOG data generally corresponds.

Recommendations:

These conclusions allowed the research team to ask the UNPKO site to provide missing data. The request included the following details: camp name, data set (Fluke or one of the LOGs), date range, and time period. Acquiring this missing data would enable the research team to conduct more robust, thorough analyses on the rest of the data.

Analytic 2: Determination of Partial or Complete Load Breakdown

Rationale:

Based on the conservation of energy within a system, the amount of power supplied to the camp should theoretically equal the amount of power consumed by the camp. This meant the amount of power supplied to the camp (Fluke) could be compared against the sum of consumption in each sector of the camp (LOGs). If the amount of power supplied equaled the amount of power consumed, it was assumed that the LOG data represents a “complete load breakdown” for that camp. This means that the demand recorded in the LOGs represents the entirety of power consumed the camp; no parts of the overall load are missing. However, if the power supplied is significantly greater than the amount of power consumed, it can be assumed that the LOG data

represents only an “incomplete load breakdown” for that camp. It means there are unknown loads not recorded in the data that are drawing power from the generators in that camp. The purpose of this analytic was to check whether the data set for each camp was a complete or an incomplete load breakdown, as recommendations for efficiency improvements are more meaningful for complete load breakdowns.

Methods:

For each camp, a time was selected randomly from the subset of times when data existed for Fluke and for each LOG sheet. The selected time and corresponding date were then recorded in the results. If there were no observations in which Fluke and LOG data were collected at exactly the same minute, data points were chosen from the Fluke and LOG sheets at the times which corresponded most closely to each other.

Once a time had been chosen and recorded, the “Active Power Total Avg” from Fluke data at that time was recorded. This number is the total power being supplied to the camp at the chosen time.

Next, the “Average Kilowatts, 3-phase system total” was recorded for each of the LOG sheets at the chosen time. Each of these represents the power being consumed at that moment in time in a given sector of the camp. The “Avg. KW, 3-phase system total” values for each LOG sheet are then summed together, and the sum is recorded in the results as “Total LOG KW”. The “Total LOG KW” value was then divided by the Fluke “Active Power Total Avg” value recorded earlier.

The results of this calculation allow conclusions to be drawn on whether the data for that camp represents a complete or an incomplete load breakdown. If the resulting fraction, when converted to a percentage, is approximately equal to 100%, the data represents a complete load breakdown. Anything less than 100%, and the data represents an incomplete load breakdown. These conclusions rely upon the assumption that the Fluke data recorded represents the only source of power distributed to the loads recorded in the LOG data. If there is another power source beyond what is recorded in the Fluke data, it cannot be determined whether the load breakdown is complete or incomplete. In order to independently verify this assumption, best practice is to consult subject matter experts (SMEs) on the data collection from the UNPKO site to determine whether unreported power sources exist. For the purposes of this study, the timeline did not allow such detailed consultation with SMEs; however, preliminary conversations indicated that the assumption was valid.

A conclusion is drawn and recorded. The calculated percentage is then subtracted from 100%, to give the percentage of “Fluke data missing.” In other words, the percentage power supplied by the Fluke generators that is not accounted for in the amount of power consumed by the LOG loads. This percentage is recorded to give an idea of the degree of completeness or incompleteness of the load breakdown.

Results:

Presented below is the example of the results for the Sector West 5-66 camp. The conclusion regarding complete or incomplete load breakdown is highlighted in yellow. Full results for other camps can be found in Appendix A2.

SECTOR WEST 5-66

Time: Thursday 1/19/2017, 11:19 (Fluke) / 11:20 (LOG)

Active Power Total Avg (VA)	144700
LOG 111 Avg. KW 3 Phase System Total	16.833
LOG 112 Avg. KW 3 Phase System Total	34.776
LOG 113 Avg. KW 3 Phase System Total	33.845
LOG 114 Avg. KW 3 Phase System Total	4.12
Total LOG KW SUM	89.574 (KW)

Comments: 38.1% of LOG data missing. **INCOMPLETE load breakdown.**

Conclusions:

The data provided by each of the six UNIFIL camps represented an incomplete load breakdown. The most complete load breakdown was Sector West 1-0A, which was missing approximately 9.2% of LOG data. The most incomplete load breakdown was Sector West 5-66, with 38.1% of LOG data missing. The UNP 8-30 Sector East campsite was missing Fluke data altogether, so Analytic 2 could not be conducted for that campsite. Meanwhile, for Sector East 7-3, the values recorded in the data actually show more power being consumed in the camp than is being supplied to the camp. Since this is physically impossible, it indicates there are additional generators supplying the camp that are not accounted for in the Fluke data. Indeed, the Excel data sheet for that camp confirmed this theory, as there were four additional 250KVA generators that were recorded in the Information sheet but not included in the Fluke data.

Recommendations:

The determination that a camp's data represents an incomplete load breakdown means that there are other loads drawing power from these generators which are not recorded in the LOG data. There could be additional sectors of the camp that rely on the same Fluke generators, but for a variety of reasons, LOG data was not collected for those sectors.

Recommendations for using generators efficiently are the most useful when a complete load breakdown exists. A complete load breakdown presents a full picture of the daily and weekly use curves for this camp, allowing for accurate recommendations which truly reflect usage rates.

Recommendations for generator usage based on an incomplete load breakdown, though still useful, will not have the same level of accuracy or precision as recommendations based on complete load breakdowns. For that reason, the overall recommendation arising from this analytic is to collect complete load breakdowns for as many camps as possible.

Analytic 3: Determination of Appropriate Generator Number

Rationale:

When functioning, generators should output electricity at the maximum of their stated capacities. For example, a diesel generator with a rating of 500 KVA will always produce 500 KVA, regardless of whether the entire quantity of energy is consumed. Given that 6 L of fuel are required to transport every 1 L used at remote mission site locations according to a 2006 study of the US military by the US Army Policy Institute (USAEPI)², it is critical to maximize efficiency.

The total available energy produced by generators throughout a camp can be compared to the total amount used at a given time to determine what combination of existing generators is most appropriate, which may be turned off, and what generator size might be best if a camp were to purchase a generator with a lesser capacity. This analysis can be done without regard to the completeness of a load breakdown, as Fluke data relating to the energy supplied to a camp is used, rather than LOG data, which is dependent upon the reporting of demand data from multiple sources. It is assumed that Fluke data is a more accurate metric of a camp's demand upon its generators than LOG.

Methods:

For each camp, "Active Power Total Average" (KW) Fluke data was compared to the calculated total available generator capacity (KVA).

Generator ratings were summed, multiplying the number of a given generator size by its rating and adding all products. Relevant information to perform this task was found either within a spreadsheet labeled "INFO" within a given file or distributed across the beginnings of LOG data sheets at the discretion of individual TCCs.

"Active Power Total Average" values were plotted over all time for which Fluke data was recorded to determine maximums. These maximum data points are the amount of energy being supplied to a camp at a given time and represent the upper limit of demand that was placed upon generators while Fluke data was being collected.

With values for maximum power supplied recorded, the amounts and percentages of unused power can be determined. Maximum power supplied was subtracted from total available generator capacity to find the amount of unused power. This value was then divided by total available generator

capacity; the quotient is a dimensionless percentage of unused energy that could be compared across campsites.

Results:

Presented below is the example of the results for the Sector West 5-66 camp. The labeled red data point indicates the maximum power supplied. Full results for other camps can be found in Appendix A3.

SECTOR WEST 5-66

Generators: 3 X 500 KVA

Total power available: 1500 KVA

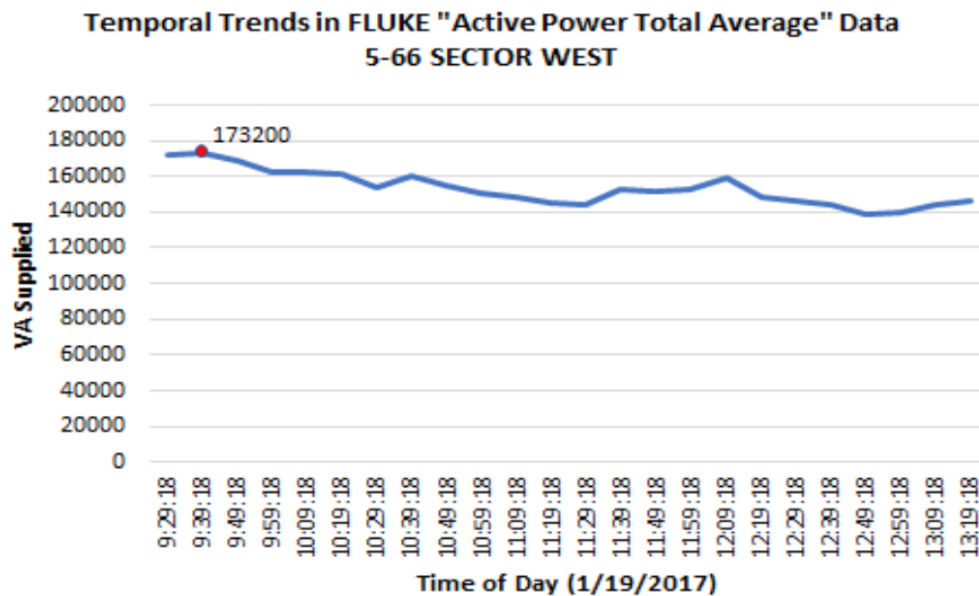
Fluke data only collected for four hours.

Maximum power supplied: 173 KVA

At peak level of use, 1327 KVA or 88.5% of total power available goes unutilized.

Recommendation:

1. 1 x 500 KVA generator is sufficient to supply camp during peak hours.
2. 2 x 500 KVA generators could be permanently turned off.
3. 1 X 250 KVA generator would also be sufficient to supply camp during peak hours.



Conclusions:

The Sector West 5-66 camp is not an ideal site for completing and reporting this analytic due to the recording of Fluke data for only four hours, during which the reported maximum power supplied may be less than the actual. At least one full 24-hour cycle would improve the accuracy of a recommendation, with extended durations providing the most accuracy. However, for the duration of Fluke data, Sector West 5-66 demonstrated the highest unused percentage of its energy: 88.5%. One additional camp (UNP 8-30 Sector East) was an unsuitable candidate for analysis due to a lack of Fluke data in its entirety; it is therefore omitted from all subsequent summations. In total, 5439 KVA energy of the reported 6370 KVA available, or 85.3%, was unused.

Recommendations:

Recorded maximum power supply data points can be used to inform recommendations about the number and rating of generators required to power a camp in three different ways. For each, the individual or collection of units most appropriately sized for the site's maximum power supplied was suggested given its existing generators. The remaining individual or collection of units that could be turned off was also noted. If the site were to purchase a new generator, the most appropriate rating of all available is listed as a third recommendation.

For Sector West 5-66, one 500 KVA existing generator is sufficient to supply camp during peak hours. Two 500 KVA generators could be permanently turned off, and one 250 KVA generator would be most efficient to supply the camp during peak hours. If a 500 KVA generator uses 37.5 gallons of diesel fuel per hour of operation³ the cost of a gallon of diesel is 14,700 Lebanese pounds⁴ (\$9.76 USD), and an analogous estimate of 5.4 gallons of gasoline fuel are required to transport 1 gallon for a total of 6.4 gallons consumed², it costs approximately \$2,342 USD to operate the unit for one hour. Extrapolating these assumptions, for each hour that 5439 KVA energy is unused across all camp sites analyzed, \$25,476 USD is wasted, assuming that all generators are operating at full capacity. If recommendations of Analytic 3 are implemented, cost savings could be tremendous.

Analytic 4: Phase Balancing

Rationale:

The purpose of this analyses was to determine how well the three different phases (L1, L2, and L3) of each camp's power system are balanced. According to Tom Decker, an Operational Energy Program Manager from the U.S. Army Corps of Engineers Construction Engineering Research Laboratory, having all phases balanced is the best condition under which to operate a power system – it is the most efficient, and the least harmful to the equipment involved⁵. The SME also suggested a margin of difference of 20% in the Average KW values for calling two phases “balanced” versus “unbalanced”. If the difference between the Avg. KW value for Phase 1 (L1) is more than 20% greater or less than the same value for Phase 2 (L2) within any one LOG data sheet, the phases are said to be unbalanced. If the difference between the two values is less than 20%, the phases are said to be balanced. If all three phases are balanced with respect to each other, the system is said to be balanced. Otherwise, the system is unbalanced.

Methods:

In order to conduct the analyses, the relevant data first had to be identified in each LOG sheet. The columns that are relevant in each LOG sheet are Avg. KW, Phase 1 (L1); Avg. KW, Phase 2 (L2); and Avg. KW, Phase 3 (L3). In order to determine whether each phase is balanced or unbalanced with each of the other phases, a total of three comparisons must be conducted: L1 versus L2, L1 versus L3, and L2 versus L3. If each of the three comparisons returns the result, “balanced,” then the system is recorded as balanced at that moment in time. If one or more of the three comparisons returns the result, “unbalanced,” then the system is recorded as unbalanced at that moment in time. In order, then, for a system to be balanced, all three of its phases must be balanced with each other at that moment.

In order to conduct each comparison, the Avg. KW value for the one phase is divided by the Avg. KW value for another phase, producing a dimensionless ratio of the two phases. This ratio is then checked against two statements – is it less than 0.8? Or is it greater than 1.2? If both these inequality statements are false, then the comparison returns a result of balanced for that moment in time, which then contributes to the overall system state of balanced. If one of the statements is true, the comparison returns a result of unbalanced for that comparison, also contributing to the determination of the overall system state of unbalanced.

Once all three comparisons are conducted for a given moment, the overall state of the system at that moment (balanced or unbalanced) is determined from the results. This overall state is then recorded for that moment. To produce the final metrics for this analytic, for each LOG sheet, the total number of instances where the system was balanced and imbalanced were recorded, and summed. The percentages of time that the system is balanced and unbalanced are calculated and recorded in the final analysis.

Results:

Below are a sample of the results of Analytic 4 conducted on the LOG data from Sector West 5-66. Analytic 4 information for all camps analyzed can be found in Appendix A4.

Sector West 5-66

LOG 111

- Loads were balanced in 104 out of 861 observations
 - Balanced 12.08% of the time
 - Unbalanced 87.92% of the time

LOG 112

- Loads were balanced in 51 out of 860 observations
 - Balanced 5.93% of the time
 - Unbalanced 93.96% of the time

LOG 113

- (Avg. KW L1 & L2 Phase missing 40+% of the time)
- Loads were balanced in 347 out of 864 observations
 - Balanced 40.16% of the time
 - Unbalanced 59.84% of the time

LOG 114

- Loads were balanced in 0 out of 861 observations
 - Balanced 0% of the time
 - Unbalanced 100% of the time

Conclusions:

Large amounts of data necessary for this analytic were not included in the data sheets. For the camps 7-1 INDO (002), Sector East 7-3, UNP 8-30 Sector East, phase data was not recorded, and phase balancing analytic could not be performed.

When data was recorded, generally, the systems spent a majority of the time with phases unbalanced. The most unbalanced systems observed were 100% unbalanced, seen in three LOGs, each in a different camp. Meanwhile, the highest percentage of time a system was balanced was also 100%, although for large periods of time in that particular LOG data sheet, the Avg. KW values were reported as zero. The next highest percentage of time spent in a balanced state was 40.16%. This means that apart from the lone 100% balanced sheet, every other LOG spent a majority of the time unbalanced.

Recommendations:

Pursuing better phase balancing should be a primary goal for UNIFIL camps, as it is currently overlooked by nearly every camp represented in the UNIFIL data. This can significantly increase efficiency across camps, and reduce strain on the technologies used. There is the most room for growth in LOGs where phases are currently balanced 0% of the time, which includes LOG 111 in Sector West 5-10, LOG 114 in Sector West 5-66, and LOG 112 in Sector West 1-0A. These camps should be instructed on the importance of phase balancing, and provided with the proper training and equipment to effectively phase balance in the various sectors of each camp.

Analytic 5: Daily Load Curves

Rationale:

This analytic calculated the daily load curves, or use curves, for each LOG sector within each UNIFIL camp. It also calculated the total daily load curve for each camp, as well as the per capita load curves for each LOG sector and each camp as a whole. Conducting these per capita calculations indirectly required a regression analysis to determine a mathematical model for predicting camp population. Additionally, each camp was characterized by the types of equipment it contained, and tagged according to a set of standard labels which included, “Hospital,” “Water Pump,” and, “Kitchen.” This allows for future comparison of energy efficiency between camps which have similar functions and equipment.

The daily load curve plots the average power consumption of a camp or a sector of a camp (in kilowatts) over the course of one 24-hour period. This allows a visual representation of which times a day experience high and low demand for electricity. The daily load curve reflects patterns of life at the camps, peaking during times of high energy demand like mealtimes or shower times.

Graphing daily load curves enables SMEs to determine, down to the hour, when generators need to be turned on or could be powered off while still meeting the demand for electricity. It visually plots demand, and makes it instantly clear when the generators being used to power a camp have been sized to meet the peak loads, not typical loads. Once such generators are identified, smaller, more efficient generators can be brought in to power the camp during non-peak hours, producing significant savings both economically and environmentally.

Method:

First, the Information sheet of each camp’s data set was analyzed to determine the proper tags for each LOG sheet. Then for each LOG sheet, a 24-hour period was selected from the overall time range of data collection. Every attempt was made to choose the same 24-hour period across all LOG sheets for a single camp. The 24-hour period was chosen to begin at midnight (0:00:00) and end at 11:50 PM the following night (24:50:00). The date of the 24-hour period chosen was recorded in the results.

For each LOG sheet, the average kilowatt, 3-phase system total values for the 24-hour period were then plotted against time, with time on the X-axis and Avg. KW, 3-Phase Total on the Y-axis. These plots for each LOG sheet were recorded in the final results.

Then, the same Avg. KW, 3-Phase Total values for each LOG sheet are summed to create an Avg. KW, 3-Phase Total column of data. This represents the power consumption of the entire camp in KW, over the same 24-hour period. It is then plotted against time to create a daily load curve for the entire camp. The maximum value on this curve is then recorded and labelled on the graph. The maximum point signals the maximum power consumed during a 24-hour time frame, and can be used to approximate the size of generator needed to supply the camp during peak usage hours.

The final graph created is each of the preceding daily load curves (one for each LOG, and then a camp total) divided by the camp population to create a combined per capita daily load curve for each camp and the LOGs within each camp. To create this graph, the Avg. KW values used in the previous graphs are simply divided by the estimated or known camp population, and graphed against time. The results are then recorded.

In the Information sheet for some UNIFIL camps, the population of men and women living in the camp was directly stated. However, this piece of data was absent from other camps' data. In order to continue with the per capita analyses, a new metric was created to estimate the number of individuals living in a camp from the number of ablutions present in the camp. Number of ablutions is often listed on the Information sheet of each camp's data, even when the population is not listed. Based on UN Modularization reports of 50-, 100-, 200-, and 1000-person camps, camp population was modeled as a function of reported ablution number (Figure 3).

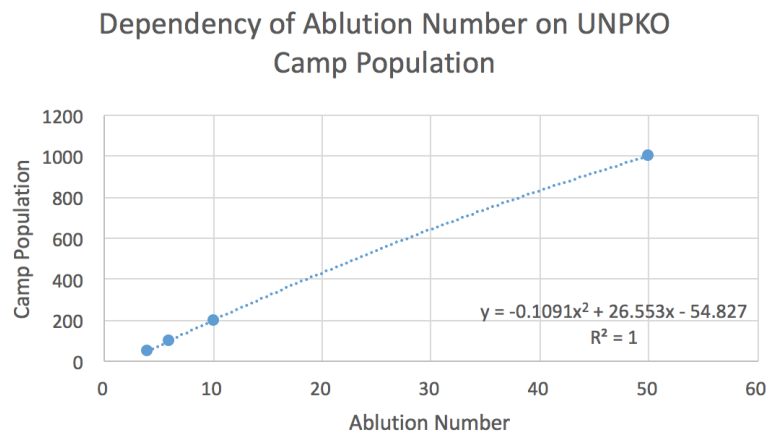


Figure 3: Modeling completed to estimate camp population size based on number of reported ablutions in DMMS data sets

Results:

Shown below are an example set of results for Camp 5-66. Included in each set of results is a standardized set of recommendations on minimum generator sizes necessary to power the camp and what sizes of generators could be eliminated at each camp.

Sector West 5-66

No Ablutions listed, besides 4 toilets

LOG Collection Tags (labels for intercamp comparison)

Officer & Regular Accommodations
Post Exchange
Hospital
ESS Workshop
ESS Offices
Gate Entrance
Shelter
Deep Well Pump
Kitchen

Given 4 toilets across all sectors recorded by LOG sheets, estimated camp size is 50.

On Jan. 20, 2017, the per capita maximum energy consumption was 90.801 KW.

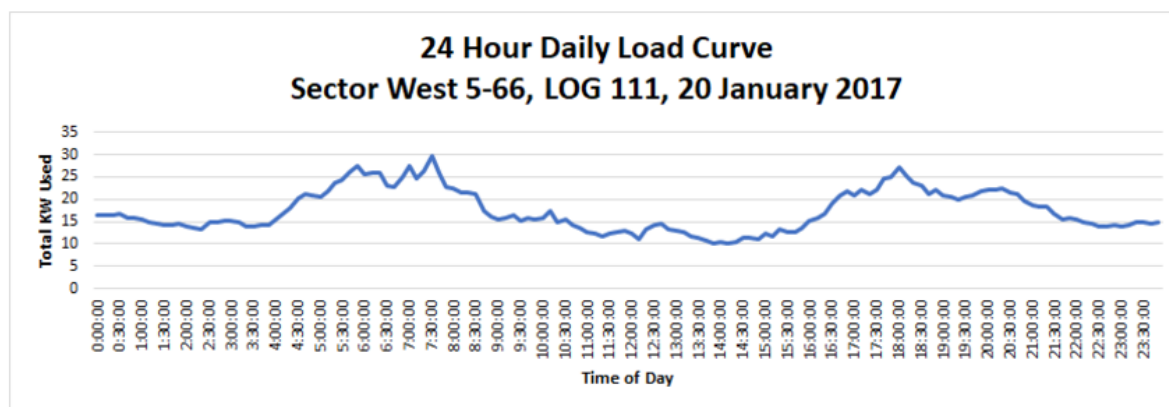
From approx. 7:00 until 16:45, the total energy usage in the camp did not exceed 90.801 KW.

Recommendations:

1. 1 x 500 KVA generator is sufficient to supply camp during peak hours.
2. 2 x 500 KVA generators could be permanently turned off.
3. 1 X 135 KVA generator would also be sufficient to supply camp during peak hours.

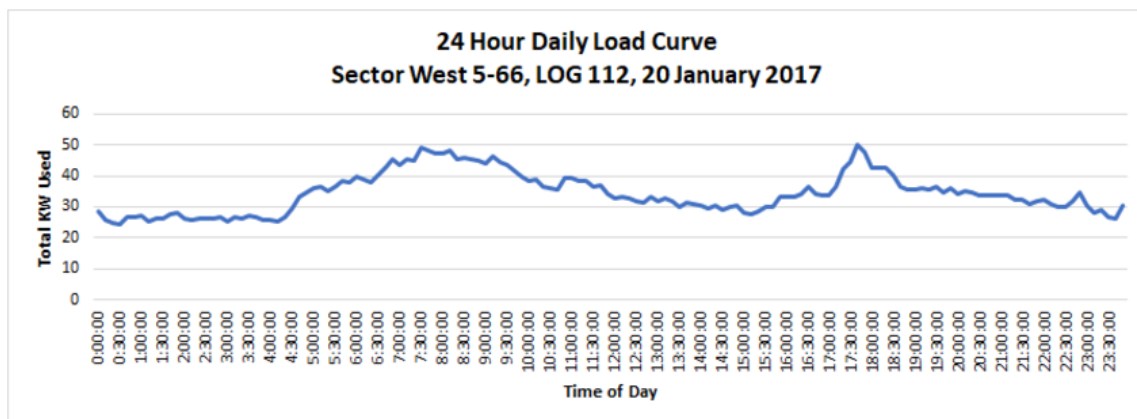
LOG 111

Tags: Hospital, Officer/Regular Accommodations, Post Exchange



LOG 112

Tags: ESS Workshop & Offices, Gate Entrance, Accommodations, Toilets, Shelter



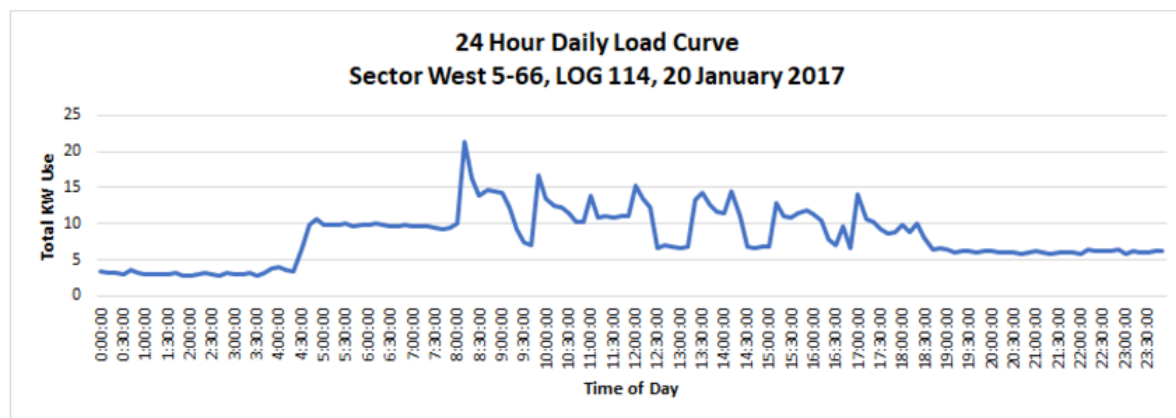
LOG 113

Tags: Deep Well Pump

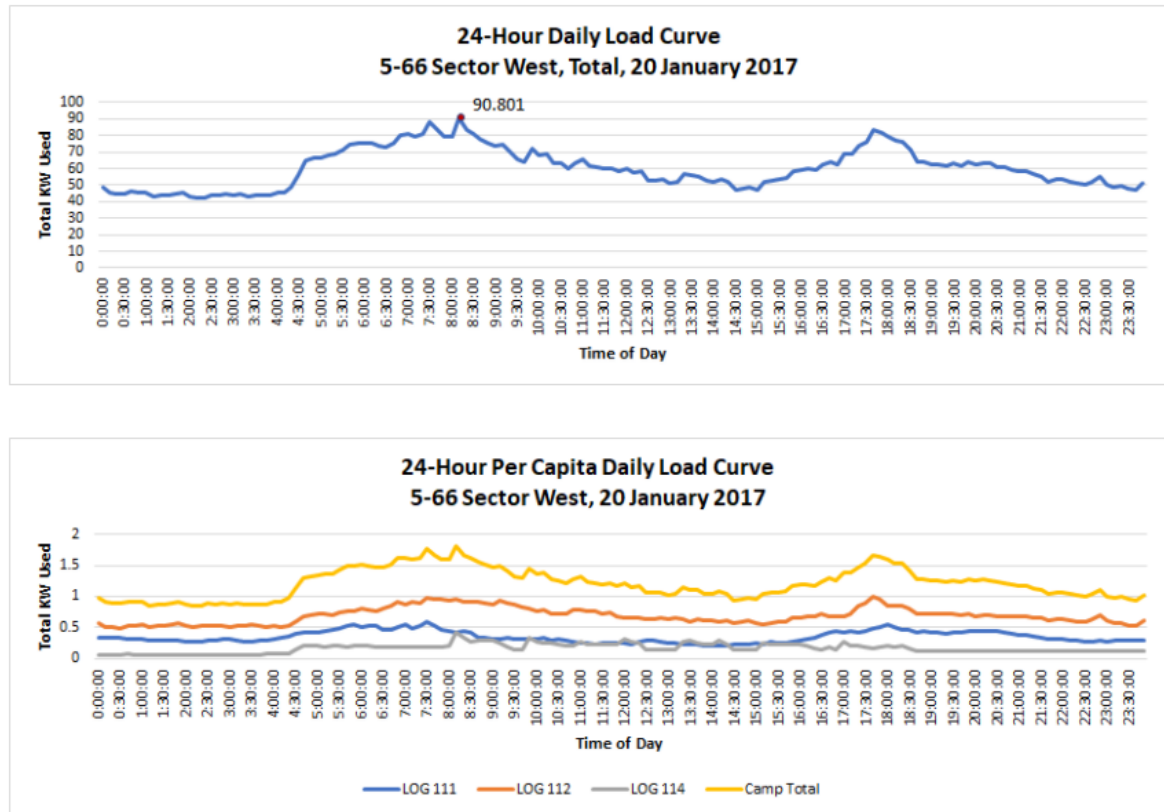
There is no 24 Hour time frame with Avg. KW 3 Phase Total data available

LOG 114

Tags: Kitchen, Freezers, Refrigerators



CAMP TOTALS



Conclusions:

Daily load curves vary significantly depending on camp population size and type of equipment located in the camp. When a LOG contains specialized equipment (for example, a water pump) as reflected in the data tags, the daily load curve looks very different from a standard daily load curve for a residential sector of a camp. The load curves can be used to identify patterns of life within the camp, including daily peaks and troughs in power consumption at the camp. Identifying these peaks and troughs can allow operators to better assign generators to meet demands without producing excess power.

Power consumption was compared across camps of varying sizes by considering consumption on a per capita basis. Power consumption per capita serves as an effective proxy for energy efficiency. The most inefficient camp was Sector West 5-66, with a peak per capita consumption of 1.75 KW per person. Meanwhile, the most efficient camp was Sector West 5-10, with a peak per capita consumption of .21 KW per person.

Recommendations:

It was discovered that in nearly every camp, generator capabilities are present that far exceed even peak daily demand, although it is unknown how many generators are actually operating at any given moment. Specific recommendations for each camp can be found in the results for Analytic 5 in Appendix A5. Removing excess generators from UNIFIL camps would reduce the overhead costs of maintaining and running generators that are unnecessary to meet demand.

Additionally, the per capita graph allows for the comparison of energy efficiency across camps of varying sizes, and the data tags allow for comparison across camps of similar purposes. From this, the most efficient UNIFIL camps should be identified and studied to determine best practices which can then be shared among camps.

Potential Regression Analyses

Analysis completed to this point has been limited to the scope of the data set itself. Regression analysis could be completed with complementary data sets to determine factors other than time of day that may influence energy consumption at a camp. For example, historical weather data could be gathered to link usage spikes to certain temperatures or other meteorological conditions (Figure 4).

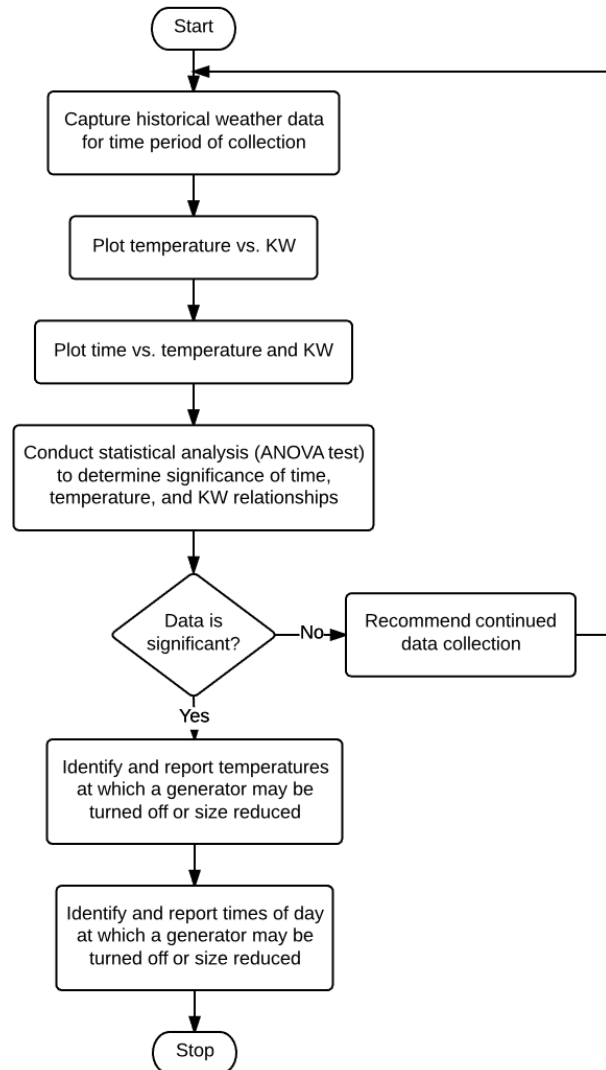


Figure 4: Sample regression analysis of DMMS data for correlating weather trends

Other analyses that could be completed might compare DMMS data to periods of increased political unrest, geographic characteristics such as altitude or rainfall, or an area's median income. Any additional metrics for determining optimal generator performance would be informative when developing management systems for camp energy usage.

Conclusion

In the course of these analyses, it was generally found that UNIFIL camps had generator capacities which far exceeded peak daily demands. From the data, it could not be determined how many generators were being used at any given moment, but it is inefficient and costly to maintain generators that are not being used. Actions could be taken across UNIFIL based on these recommendations to lower costs by eliminating unused generators.

Additionally, the DMMS data received proved difficult to analyze, due to a lack of standardization and background information. Providing more background documentation as to the significance of the data, as well as standardizing the methods and formats of collecting data, would make the analytic process more scalable and repeatable.

The analytical process developed in this report can be expanded to analyze similar DMMS data from other UNIFIL camps, or even other UNPKO missions. The recommendations in this study could be used to determine appropriately-sized generators and develop schedules for usage. Within the constraints of UNPKO-approved technology and budget, it may be more feasible to simply phase out the use of unneeded technology or transfer it between locations than to purchase new equipment. In the future, a guide for implementation and usage of DMMS analysis itself may be helpful in standardizing collection methodology across camps.

Appendix A

Appendix A1

Analytic 1: Fluke vs. Log Data Collection Periods

Highlighted cells note discrepancies in the data.

7-1 INDO (002)

	Collection Start	Collection End
Fluke	11/3/2016 10:26	11/10/2016 9:56
LOG 111	11/3/2016 11:20	11/10/2016 10:10
LOG 112	11/3/2016 10:40	11/10/2016 10:00
LOG 113	11/3/2016 11:30	11/10/2016 10:00
LOG 114	11/3/2016 11:00	11/10/2016 10:10

Comments: Fluke and LOG data generally correspond.

SECTOR EAST 7-3

	Collection Start	Collection End
Fluke	12/1/2016 13:21	12/20/2016 20:01
LOG 111	12/1/2016 13:30	12/20/2016 15:20
LOG 113	12/1/2016 12:40	12/11/2016 12:40
LOG 114	12/1/2016 13:20	12/20/2016 15:10

Comments: Fluke and LOG data correspond except on sheet LOG 113, where data is missing. Is this worth asking about, or probably not because all relevant Fluke data is accounted for?

SECTOR WEST 5-10

	Collection Start	Collection End
Fluke	1/6/2017 09:32	1/16/2017 09:12

LOG 111	1/6/2017 10:10	1/9/2017 8:50
LOG 112	1/6/2017 09:00	1/16/2017 09:10
LOG 113	1/6/2017 09:50	1/16/2017 09:00
LOG 114	1/6/2017 10:00	1/16/2017 09:00

Comments: Fluke data corresponds to the majority of LOG data.

SECTOR WEST 5-66

	Collection Start	Collection End
Fluke	1/19/2017 09:19	1/19/2017 13:19
LOG 111	1/19/2017 09:30	1/25/2017 09:00
LOG 112	1/19/2017 10:00	1/25/2017 09:20
LOG 113	1/19/2017 09:30	1/25/2017 08:50
LOG 114	1/19/2017 09:50	1/25/2017 09:10

Comments: Fluke data lasts only 4 hours, LOG data was recorded over 6 days. Same start time for all data sets.

UNP 8-30 Sector East

	Collection Start	Collection End
Fluke	No data	No data
LOG 1	11/24/2016 13:20	12/1/2016 10:50
LOG 2	11/24/2016 13:00	12/1/2016 09:30
LOG 3	11/24/2016 12:40	12/1/2016 10:10
LOG 4	11/24/2016 12:20	12/1/2016 10:00

Comments: Fluke data does not exist, slight discrepancies in start and end LOG times.

SECTOR WEST 1-0A

	Collection Start	Collection End
Fluke	12/22/2016 09:54	12/24/2016 15:54
LOG 111	12/22/2016 10:20	1/3/2017 11:50
LOG 112	12/22/2016 10:40	1/3/2017 11:50
LOG 113	12/22/2016 11:00	1/3/2017 11:30
LOG 114	12/22/2016 11:00	1/3/2017 11:50

Comments: Fluke data covers only the two and a half days of LOG data; the last week and a half of Fluke data is missing. Discrepancies in LOG start and end times is negligible.

Appendix A2

Analytic 2: Determination of Full or Partial Load Breakdown

7-1 INDO (002)

Time: Thursday 11/3/2016, 11:26 (Fluke) / 11:20 (LOG)

<i>Active Power Total Avg (VA)</i>	78600
LOG 111 Avg. KW 3 Phase System Total	9.318
LOG 112 Avg. KW 3 Phase System Total	24.54
LOG 113 Avg. KW 3 Phase System Total	22.738
LOG 114 Avg. KW 3 Phase System Total	1.273
<i>Total LOG KW</i>	57.869

Comments: Approximately 26.4% of LOG data is missing. INCOMPLETE load breakdown.

SECTOR EAST 7-3

Time: Thursday 12/1/2016, 13:31 (Fluke) / 13:30 (LOG)

<i>Active Power Total Avg (VA)</i>	138200
LOG 111 Avg. KW 3 Phase System Total	82.981

LOG 113 Avg. KW 3 Phase System Total	66.184
LOG 114 Avg. KW 3 Phase System Total	59.956
<i>Total LOG KW</i>	209.121

Comments: There is a 51.3% increase from Fluke to LOG data. Here, the load breakdown may be complete, but Fluke does not reflect this total load. **INCOMPLETE data**. Is it possible that a generator was used to provide power to sectors that was not captured in Fluke data?

(8/5/2017) - YES, there are additional generators. 4 X 250 KVA generators provide power recorded by LOG 113 not accounted for in Fluke. If these are manually added to the Active Power Total Avg value, it becomes 238200 VA. This means approximately 12.2% of LOG data is missing. **INCOMPLETE load breakdown**.

SECTOR WEST 5-10

Time: Friday 1/6/2017, 11:22 (Fluke) / 11:20 (LOG)

<i>Active Power Total Avg (VA)</i>	90300
LOG 111 Avg. KW 3 Phase System Total	2.529
LOG 112 Avg. KW 3 Phase System Total	3.371
LOG 113 Avg. KW 3 Phase System Total	14.027
LOG 114 Avg. KW 3 Phase System Total	55.534
<i>Total LOG KW</i>	75.461

Comments: 17.4% LOG data missing. **INCOMPLETE load breakdown**.

SECTOR WEST 5-66

Time: Thursday 1/19/2017, 11:19 (Fluke) / 11:20 (LOG)

<i>Active Power Total Avg (VA)</i>	144700
LOG 111 Avg. KW 3 Phase System Total	16.833
LOG 112 Avg. KW 3 Phase System Total	34.776
LOG 113 Avg. KW 3 Phase System Total	33.845

LOG 114 Avg. KW 3 Phase System Total	4.12
<i>Total LOG KW</i>	89.574

Comments: 38.1% of LOG data missing. INCOMPLETE load breakdown.

UNP 8-30 Sector East

Time: Saturday 11/26/2016, 16:30 (LOG)

<i>Active Power Total Avg (VA)</i>	No Fluke Data Available
LOG 1 Avg. KW 3 Phase System Total	8.448
LOG 2 Avg. KW 3 Phase System Total	38.264
LOG 3 Avg. KW 3 Phase System Total	8.888
LOG 4 Avg. KW 3 Phase System Total	34.652
<i>Total LOG KW</i>	90.252

Comments: Because no Fluke data exists, completeness of load breakdown cannot be determined.
UNDETERMINED load breakdown.

SECTOR WEST 1-0A

Time: Saturday 12/24/2016, 15:04 (Fluke) / 15:00 (LOG)

<i>Active Power Total Avg (VA)</i>	117200
LOG 111 Avg. KW 3 Phase System Total	47.147
LOG 112 Avg. KW 3 Phase System Total	20.219
LOG 113 Avg. KW 3 Phase System Total	11.855
LOG 114 Avg. KW 3 Phase System Total	27.202
<i>Total LOG KW</i>	106.423

Comments: Approximately 9.2% of LOG data is missing. INCOMPLETE load breakdown.

Appendix A3

Analytic 3: Determination of Appropriate Generator Number

7-1 INDO (002)

Generators: 2 x 500 KVA, 1 x 370 KVA

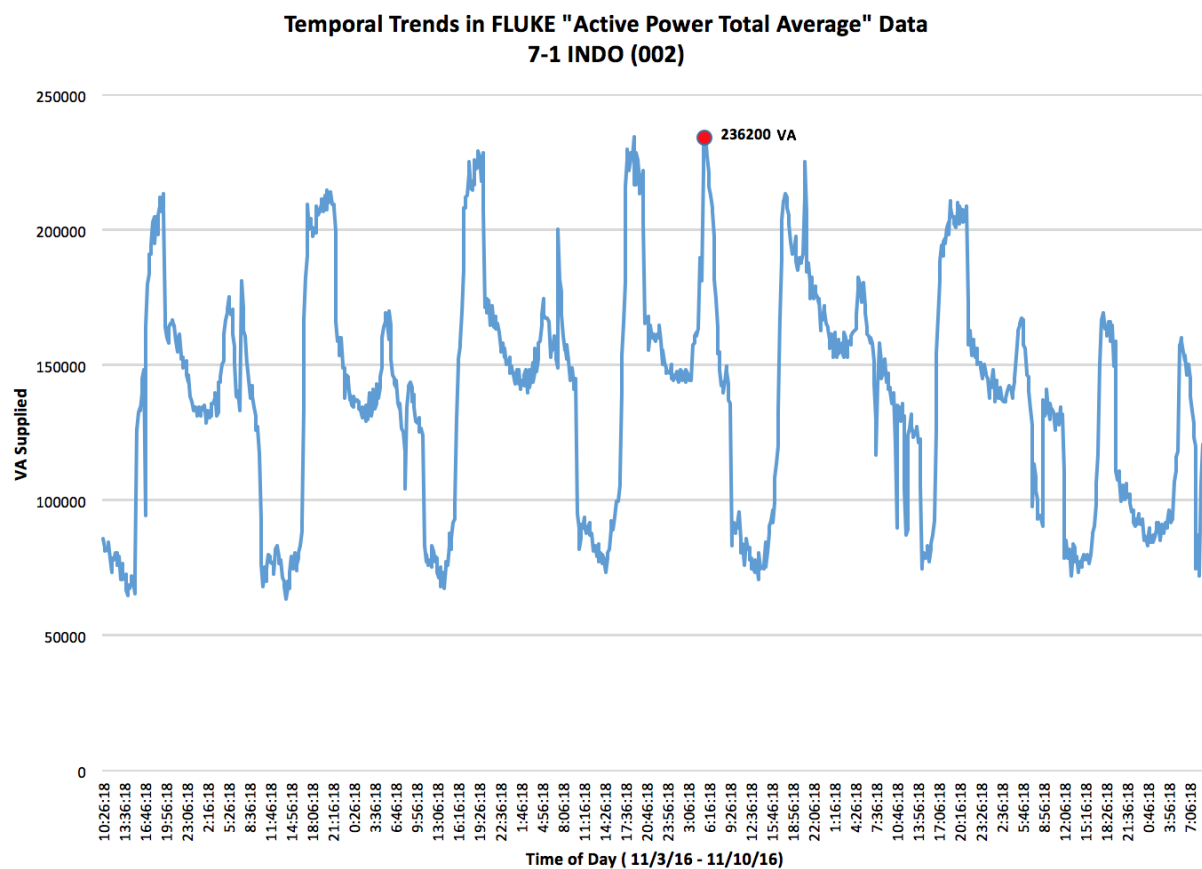
Total power available: 1370 KVA

Maximum power supplied: 236 KVA

At peak level of use, 1134 KVA or 82.8% of total power available goes unutilized.

Recommendation:

1. 1 x 370 KVA generator is sufficient to supply camp during peak hours.
2. 2 x 500 KVA generators could be permanently turned off.
3. 1 X 250 KVA generator would also be sufficient to supply camp during peak hours.



SECTOR EAST 7-3

Generators: 2 X 500 KVA, 4 X 250 KVA

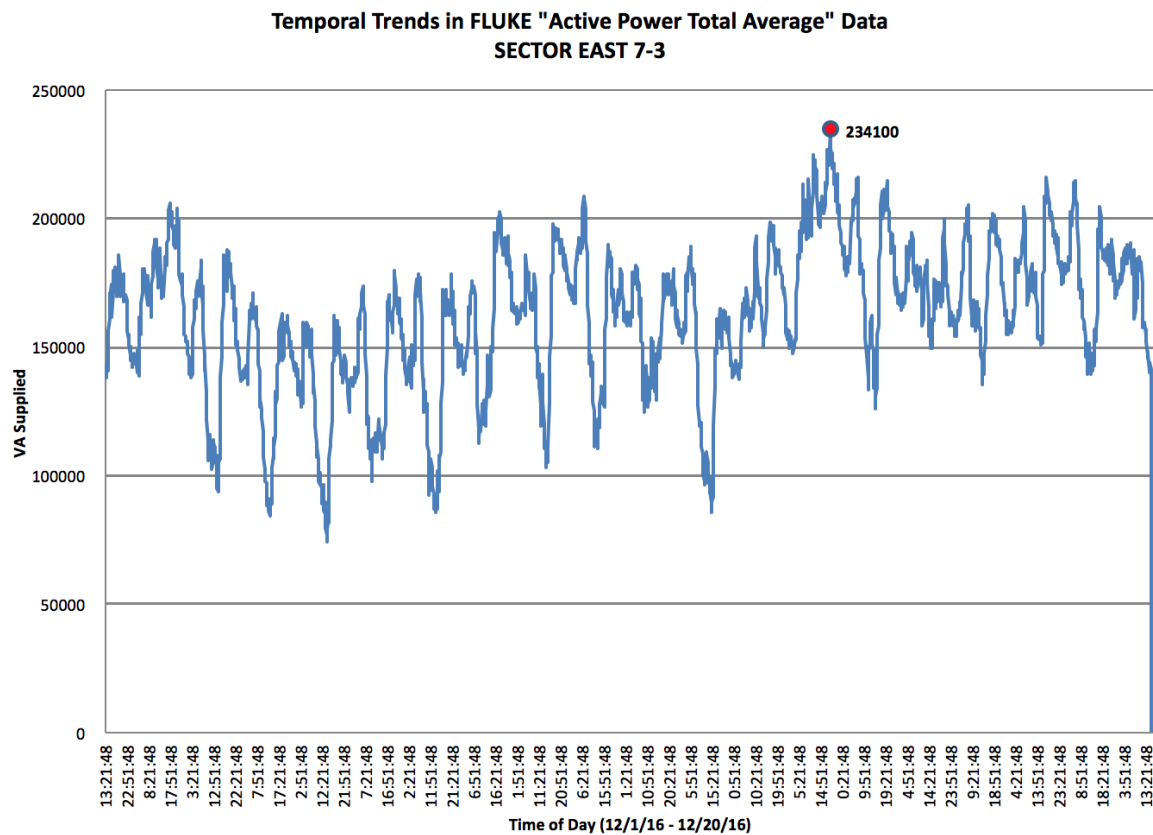
Total power available: 2000 KVA

Maximum power supplied: 234 KVA

At peak level of use, 1766 KVA or 88.3% of total power available goes unutilized.

Recommendation:

1. 1 x 250 KVA generator is sufficient to supply camp during peak hours.
2. 2 x 500 KVA and 3 X 250 KVA generators could be permanently turned off.
3. No additional generator sizes would be needed to supply for camp needs.



SECTOR WEST 5-10

Generators: 3 X 250 KVA

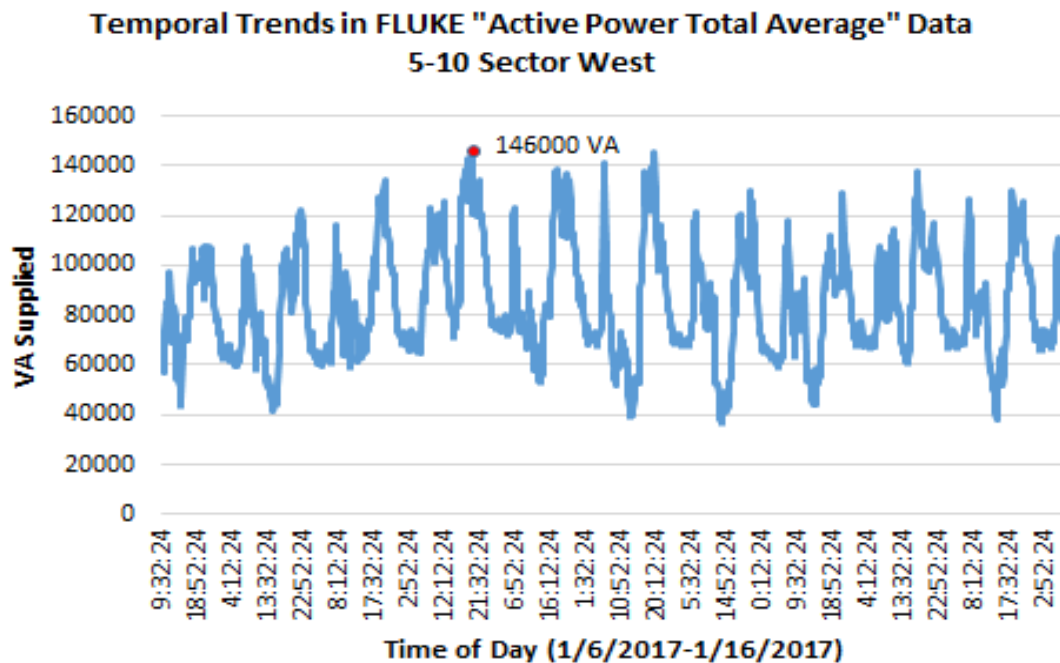
Total power available: 750 KVA

Maximum power supplied: 146 KVA

At peak level of use, 604 KVA or 80.5% of total power available goes unutilized.

Recommendation:

1. 1 x 250 KVA generator is sufficient to supply camp during peak hours.
2. 2 x 250 KVA generators could be permanently turned off.
3. 1 X 250 KVA generator would also be sufficient to supply camp during peak hours.



SECTOR WEST 5-66

Generators: 3 X 500 KVA

Total power available: 1500 KVA

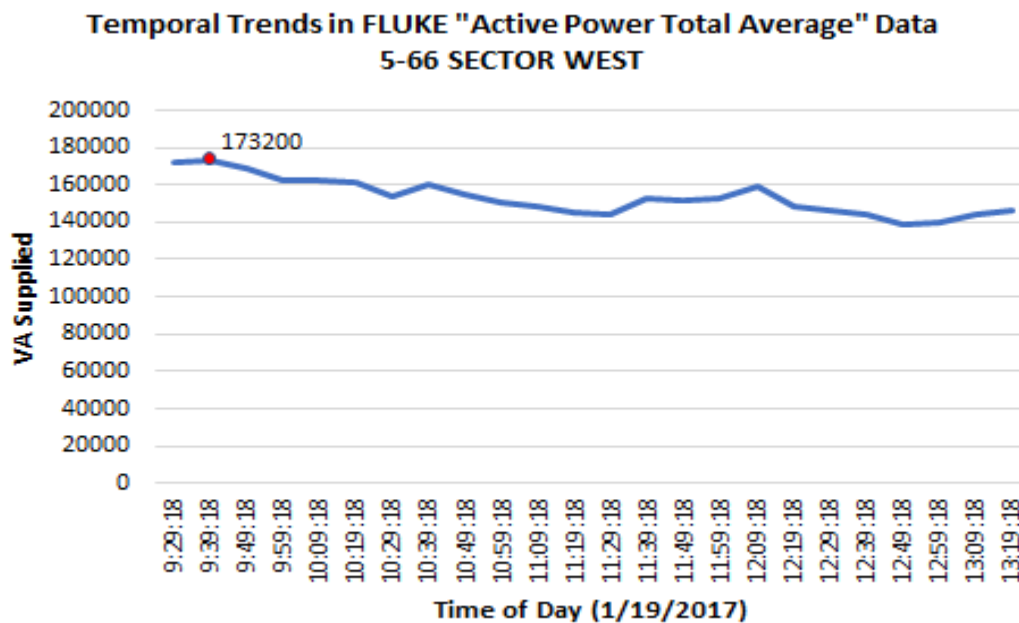
Fluke data only collected for four hours.

Maximum power supplied: 173 KVA

At peak level of use, 1327 KVA or 88.5% of total power available goes unutilized.

Recommendation:

1. 1 x 500 KVA generator is sufficient to supply camp during peak hours.
2. 2 x 500 KVA generators could be permanently turned off.
3. 1 X 250 KVA generator would also be sufficient to supply camp during peak hours.



UNP 8-30 Sector East

Generators: 2 X 80 KVA, 2 X 135 KVA, 2 X 45 KVA, 1 X 62.5 KVA

Total power available: 582.5 KVA

Maximum power supplied: Unknown, no Fluke data was collected.

Recommendations & Graph could not be generated, because no Fluke data was collected.

Sector West 1-0A

Generators: 3 x 250 KVA

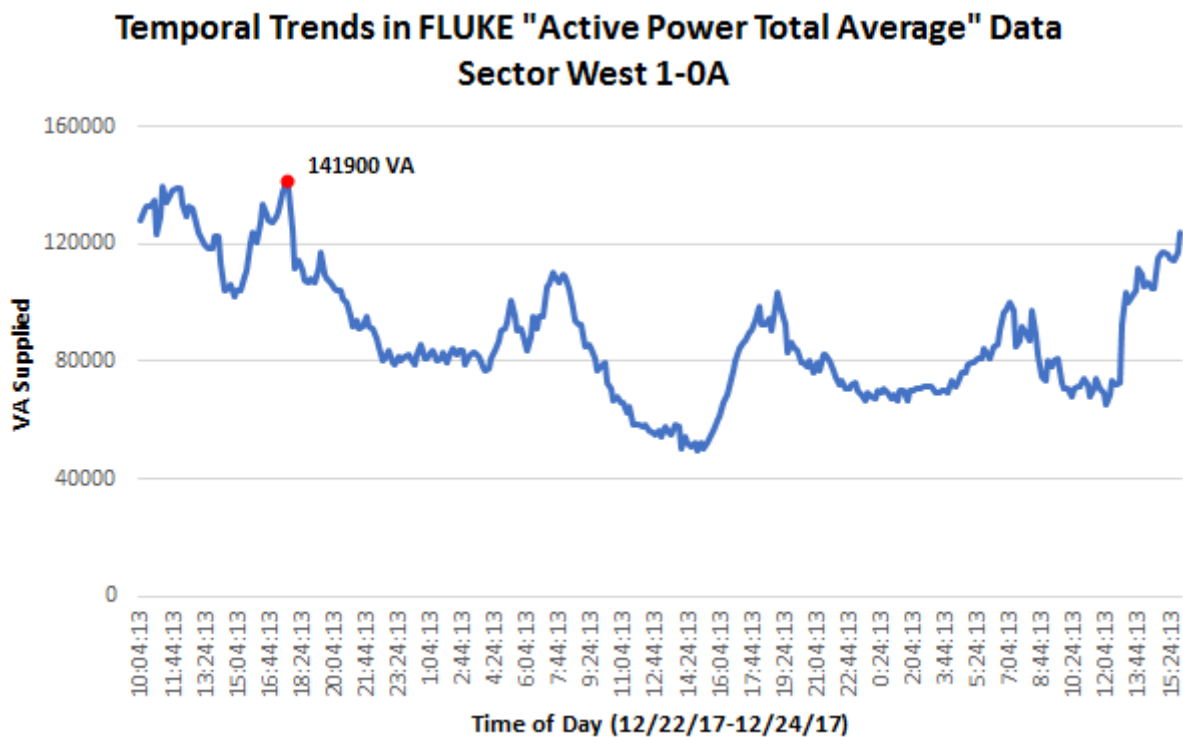
Total power available: 750 KVA

Maximum power supplied: 142 KVA

At peak level of use, 608 KVA or 81.1% of total power available goes unutilized.

Recommendation:

4. 1 x 250 KVA generator is sufficient to supply camp during peak hours.
5. 2 x 250 KVA generators could be permanently turned off.
6. 1 X 250 KVA generator is the best option to supply camp during peak hours.



Appendix A4

Analytic 4: Comparison of Phase Balancing in L1, L2, and L3 Phases

General Findings / Method Validation

Based on a small difference in ranges between all, unbalanced, and balanced data, it is assumed that there is no minimum or maximum value that would cause outlying data to become unbalanced.

It was noted that some days are unbalanced for the entire period, suggesting that there is no daily temporal trend in balanced vs. unbalanced load cycles.

“Unbalanced” is defined as a difference between phases greater than 20%⁵.

7-1 INDO (002)

No individual phases (L1, L2, L3) recorded for any LOG sheets.

SECTOR EAST 7-3

No individual phases (L1, L2, L3) recorded for any LOG sheets.

Sector West 5-10

LOG 111

- Loads were balanced in 0 out of 424 observations
 - Balanced 0% of the time
 - Unbalanced 100% of the time

LOG 112

- Loads were balanced in 5 out of 1435 observations
 - Balanced .35% of the time
 - Unbalanced 99.65% of the time

LOG 113

- (Avg. KW L1 & L2 Phase missing 80+% of the time)

LOG 114

- Loads were balanced in 6 out of 1434 observations
 - Balanced .42% of the time
 - Unbalanced 99.58% of the time

Sector West 5-66

LOG 111

- Loads were balanced in 104 out of 861 observations
 - Balanced 12.08% of the time
 - Unbalanced 87.92% of the time

LOG 112

- Loads were balanced in 51 out of 860 observations
 - Balanced 5.93% of the time
 - Unbalanced 93.96% of the time

LOG 113

- (Avg. KW L1 & L2 Phase missing 40+% of the time)
- Loads were balanced in 347 out of 864 observations
 - Balanced 40.16% of the time
 - Unbalanced 59.84% of the time

LOG 114

- Loads were balanced in 0 out of 861 observations
 - Balanced 0% of the time
 - Unbalanced 100% of the time

UNP 8-30 Sector East

No individual phases (L1, L2, L3) recorded for any LOG sheets.

Sector West 1-0A

LOG 111

- Loads were balanced in 187 out of 1718 observations
 - Balanced 10.9% of the time
 - Unbalanced 89.1% of the time

LOG 112

- Loads were balanced in 0 out of 1717 observations
 - Balanced 0% of the time
 - Unbalanced 100% of the time

LOG 113

- Loads were balanced in 237 out of 1715 observations
 - Balanced 13.8% of the time
 - Unbalanced 86.2% of the time

LOG 114

- Loads were balanced in 1715 out of 1715 observations
 - Balanced 100% of the time
 - Unbalanced 0% of the time
 - Large periods of time where L1, L2, L3 Avg. KW were 0

Appendix A5

Analytic 5: Analysis of daily load curves to identify cyclic loading trends

Camp size estimation (based on reference materials)

50-person camp: 4 ablution modules (2 X 20' shower containers, 2 X 20' WC containers)

100-person camp: 6 ablution modules (3 X 20' shower containers, 3 X 20' WC containers)

200-person camp: 10 ablution modules (4 X 20' shower containers, 6 X 20' WC containers)

1000-person camp: 50 ablution modules (21 X 20' shower containers, 29 X 20' WC containers)

LOG Collection Tags (labels for intercamp comparison)

Kitchen

Cafeteria

Living Quarters

Water Pump

Hospital

It is expected that these above categories will drive distinct energy consumption trends, so label LOG sheets with multiple tags if they contain, for example, data related to both a kitchen and living quarters.

7-1 INDO (002)

Given 14 ablutions across all sectors recorded by LOG sheets, estimated camp size is 296 people.

On Nov. 9, 2016, the per capita maximum energy consumption was 0.419 KW.

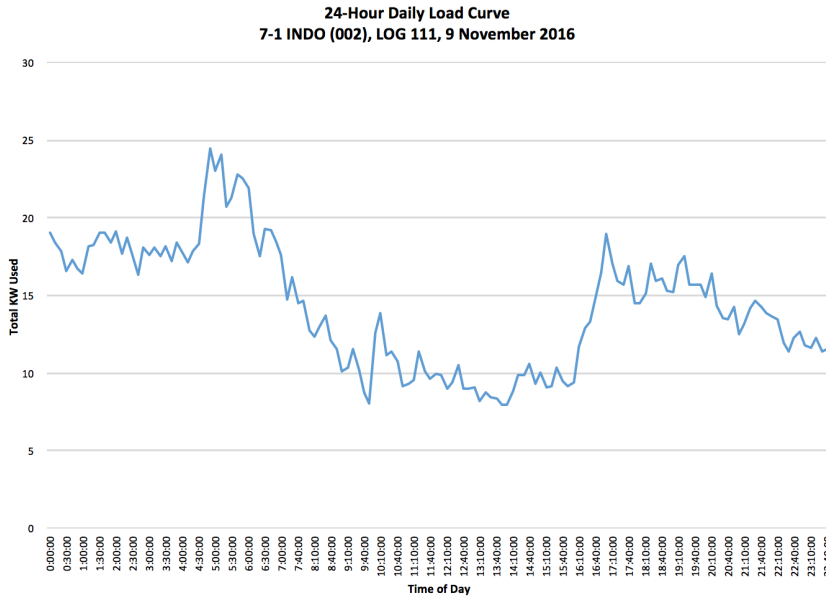
From approx. 7:00 until 16:45, the total energy usage in the camp did not exceed 100 KW.

Recommendations:

1. 1 X 370 KVA generator is sufficient to supply camp from 7:00 until 16:45.
2. 2 X 500 KVA generators could be permanently turned off.
3. 1 X 100 KVA generator would also be sufficient to supply camp during slow hours.

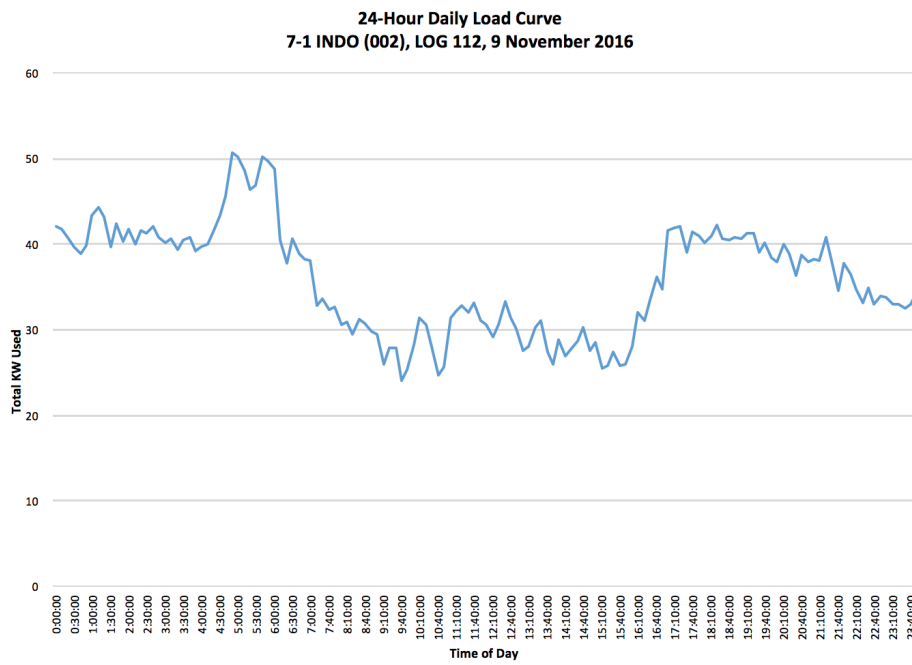
LOG 111

Tags: Kitchen, Living Quarters



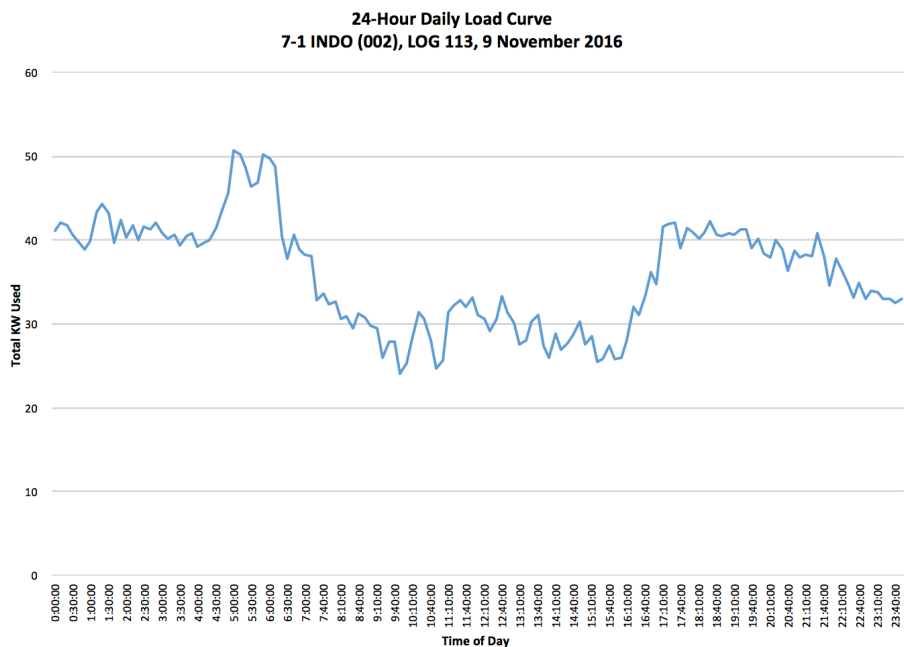
LOG 112

Tags: Kitchen, Cafeteria, Living Quarters



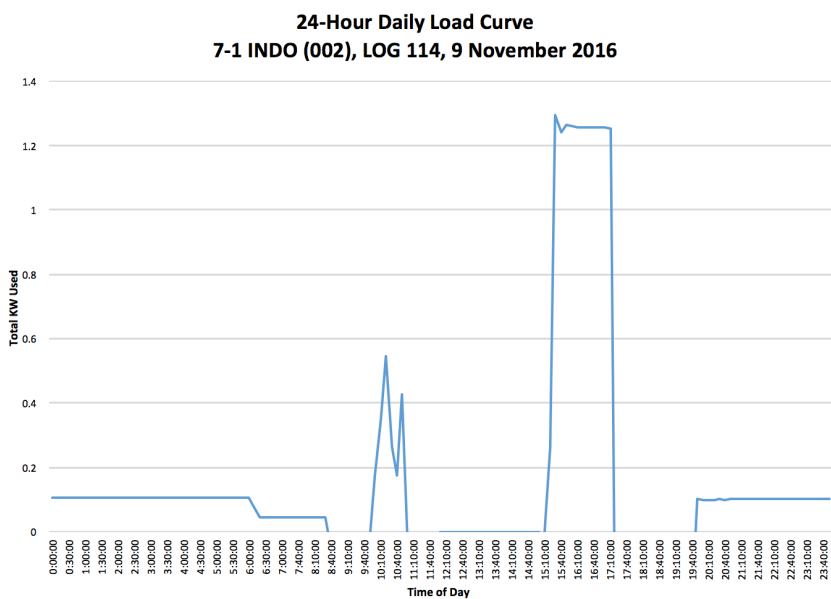
LOG 113

Tags: Living Quarters



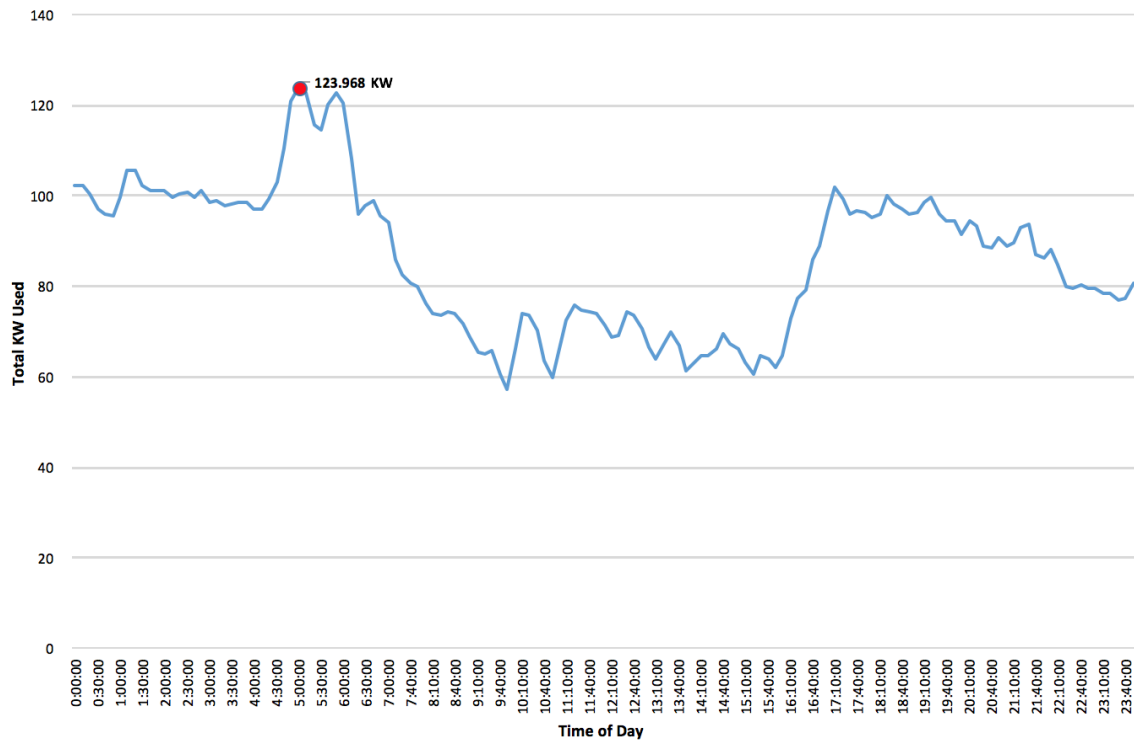
LOG 114

Tags: Water Pump

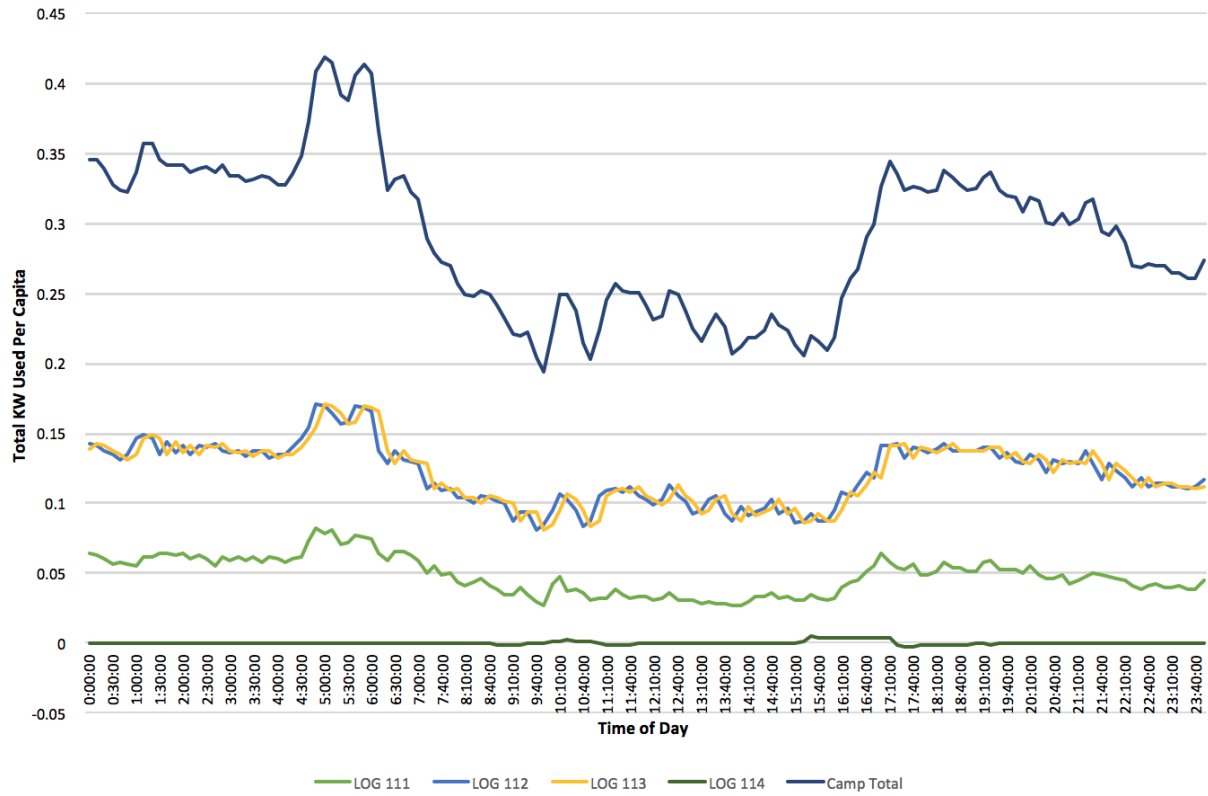


CAMP TOTALS

24-Hour Daily Load Curve
7-1 INDO (002), Total, 9 November 2016



24-Hour Per Capita Daily Load Curve
7-1 INDO (002), 9 November 2016



SECTOR EAST 7-3

Given 29 ablutions across all sectors recorded by LOG sheets, estimated camp size is 623 people.

On Dec. 7, 2016, the per capita maximum energy consumption was 269 KW (interestingly, this is about 30 KW more than the maximum KVA supplied, as noted in Fluke).

From approx. 8:30 until 16:00, the total energy usage in the camp did not exceed 200 KW.

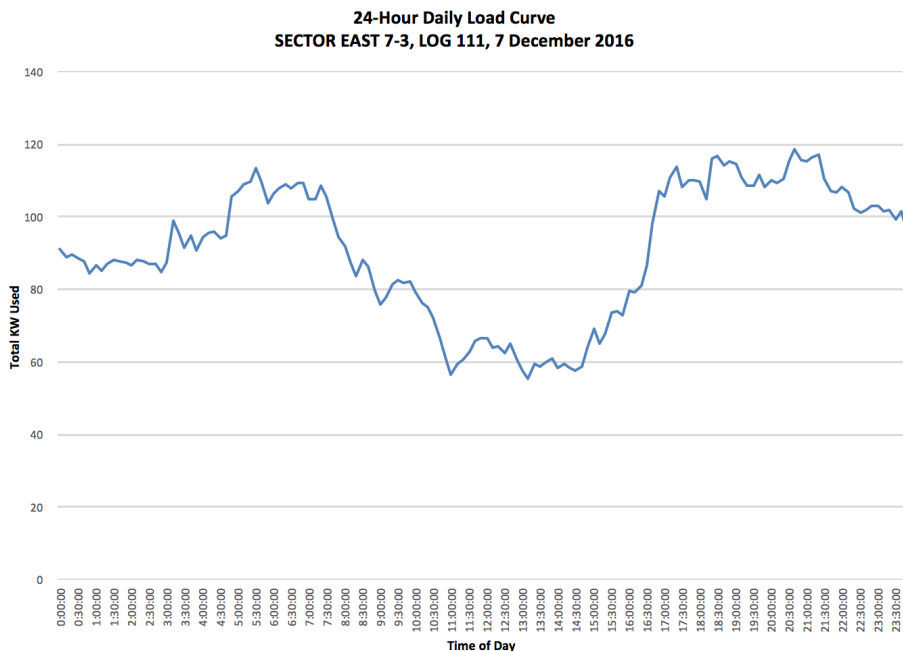
Recommendations:

1. 1 X 250 KVA generator is sufficient to supply camp from 8:30 until 16:00.
2. 2 X 500, 2 X 250 KVA generators could be permanently turned off.
3. 1 X 250 KVA generator would also be sufficient to supply camp during slow hours.

It was observed that for LOG 113 data, no measurement was recorded at 5:00, 8:50, 12:50, 16:50, and 22:00. This resulted in sharp downward spikes on the graph.

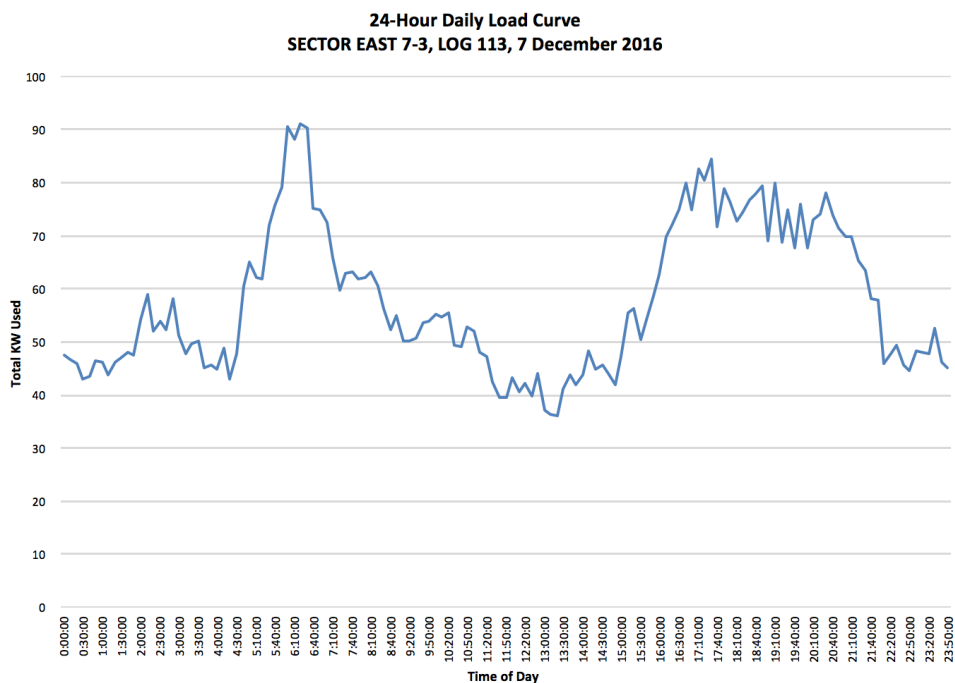
LOG 111

Tags: Water Pump, Living Quarters



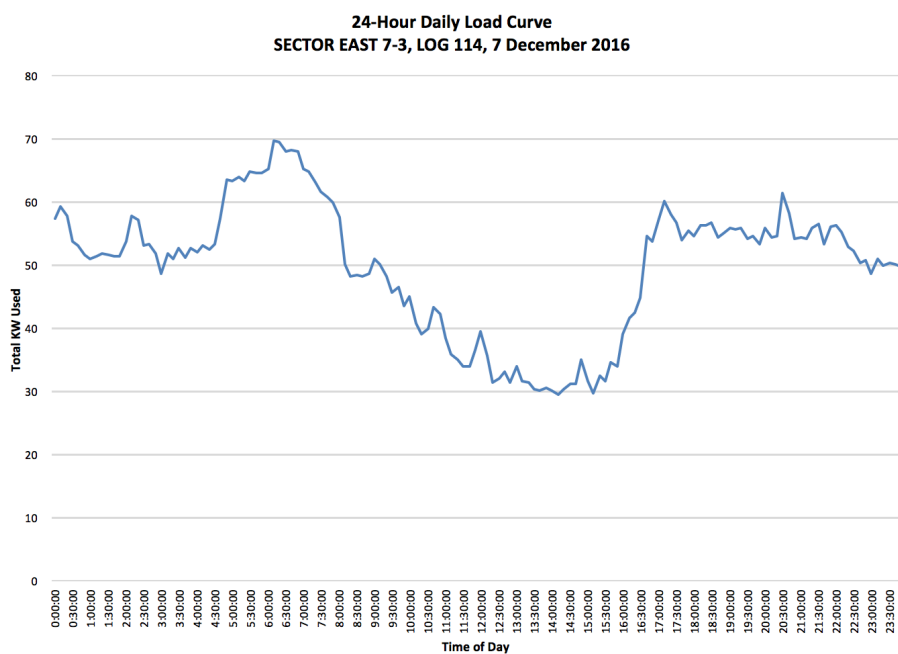
LOG 113

Tags: Kitchen, Hospital, Living Quarters



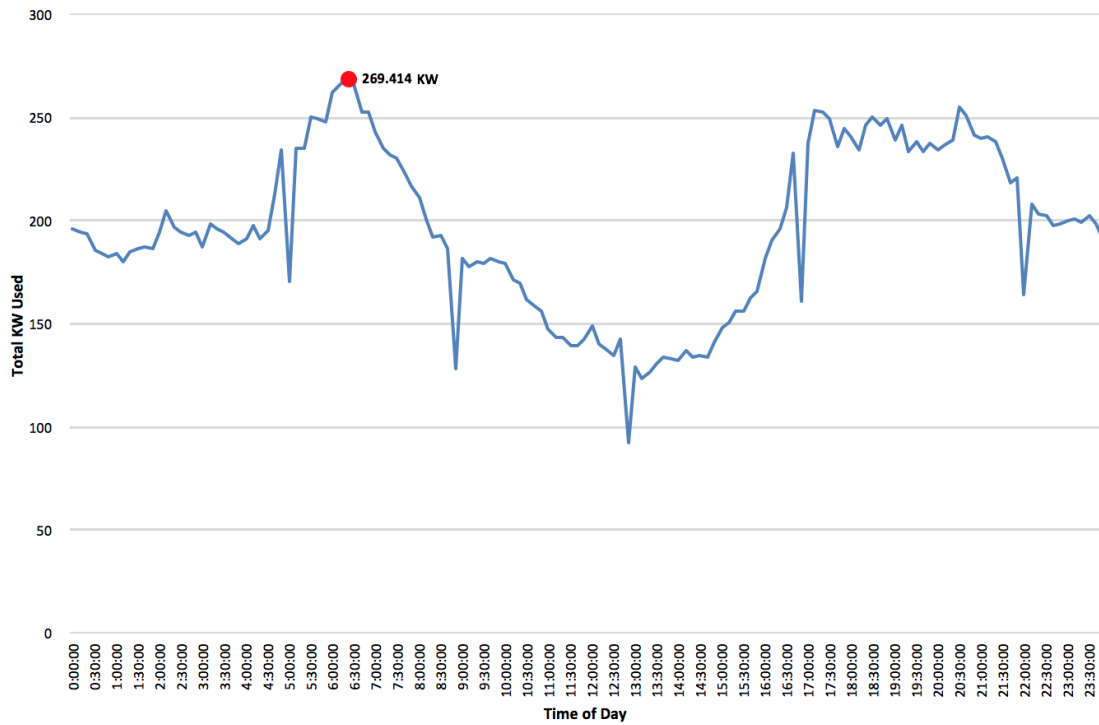
LOG 114

Tags: Kitchen, Cafeteria, Living Quarters

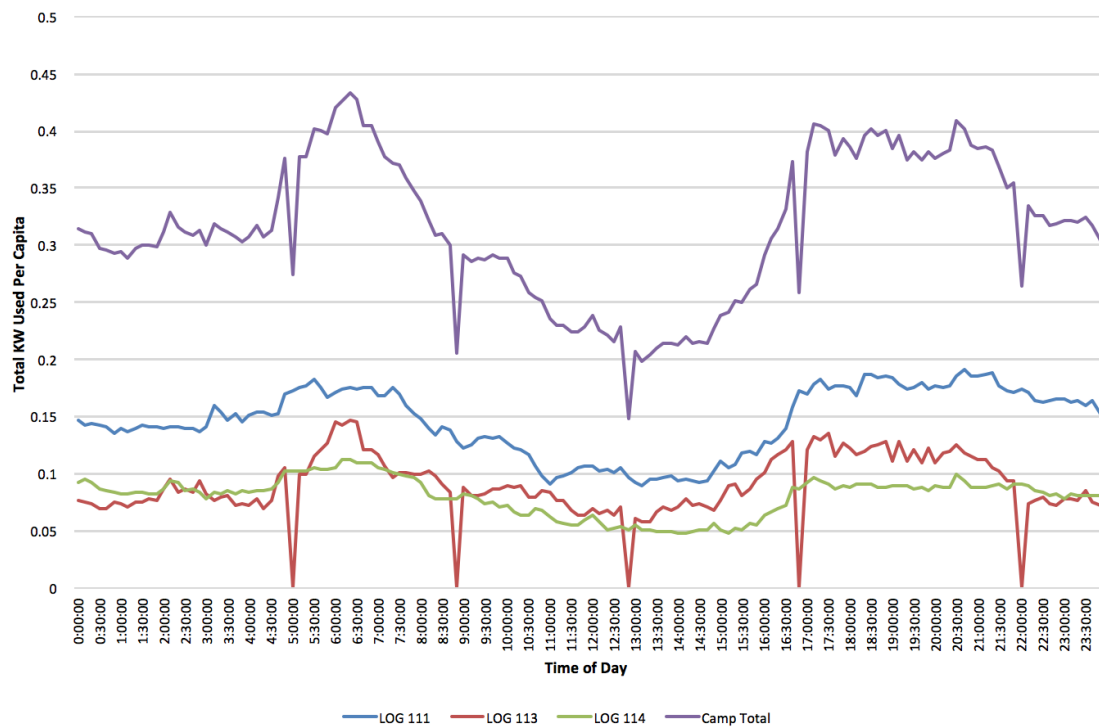


CAMP TOTALS

24-Hour Daily Load Curve
SECTOR EAST 7-3, Total, 7 December 2016



24-Hour Per Capita Daily Load Curve
SECTOR EAST 7-3, 7 December 2016



Sector West 5-10

9 Ablution Modules -- Document lists 400 people

LOG Collection Tags (labels for intercamp comparison)

Hospital
Kitchen
Rubhall
Deep Well
Workshop
Accommodations
Ablutions

Given 9 ablutions across all sectors recorded by LOG sheets, estimated camp size is 185 people.

On Jan. 7, 2017, the per capita maximum energy consumption was 87.473 KW.

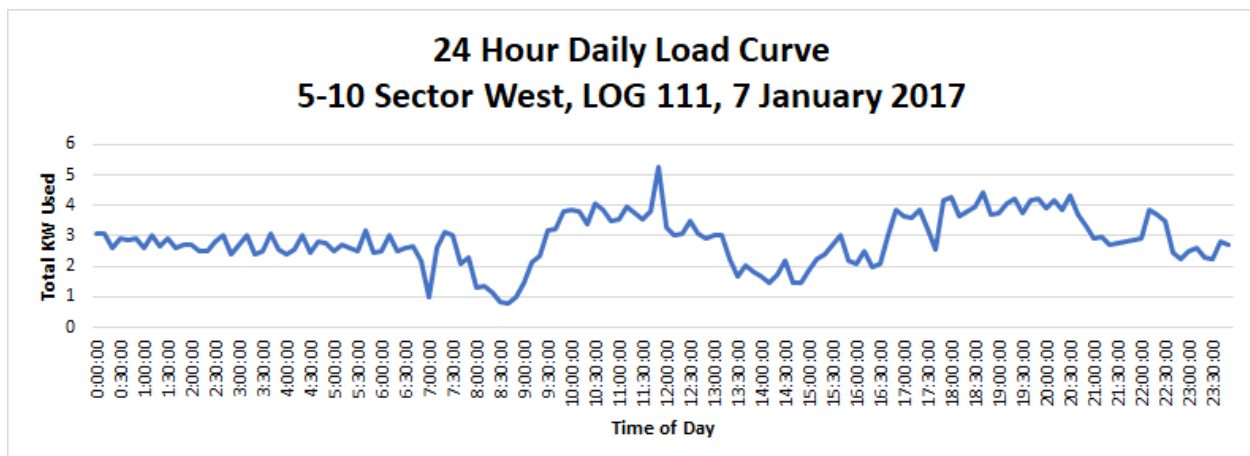
From approx. 7:00 until 16:45, the total energy usage in the camp did not exceed 250KW.

Recommendations:

1. 1 X 250 KVA generator is sufficient to supply camp for all hours of the day.
2. 2 X 250 KVA generators could be permanently turned off.
3. 1 X 135 KVA generator would also be sufficient to supply camp during all hours.

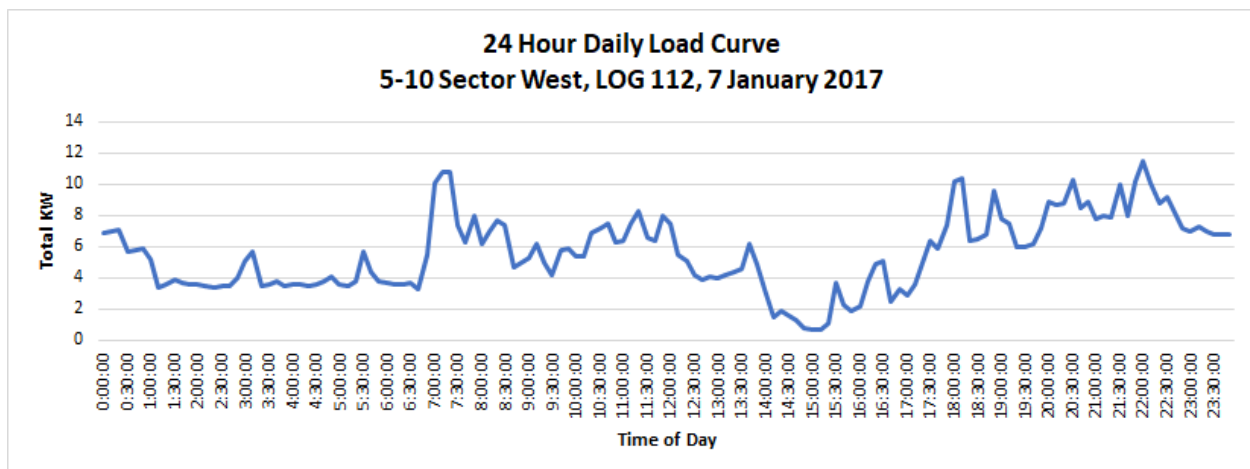
LOG 111

Tags: Hospital, Accommodations, Ablutions



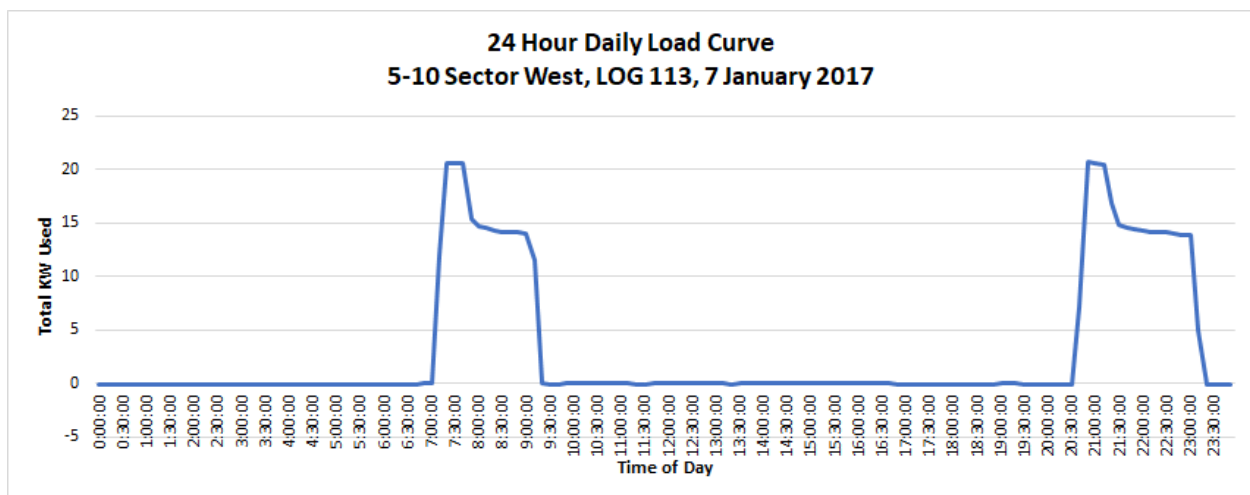
LOG 112

Tags: Kitchen, Rubhall, Accommodations, Ablutions



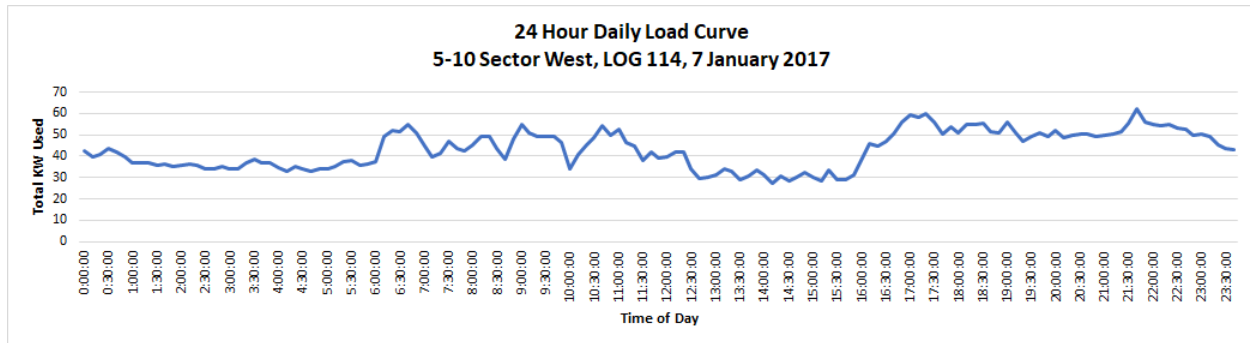
LOG 113

Tags: Deep Well

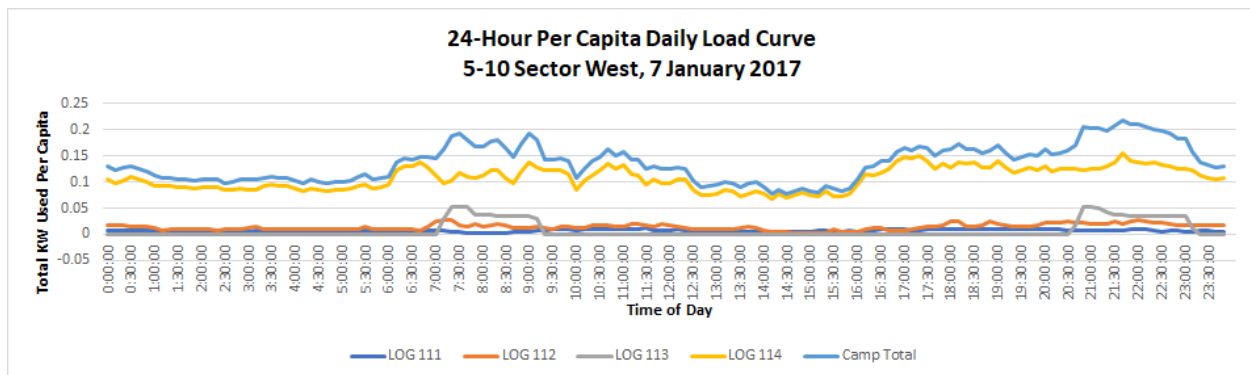
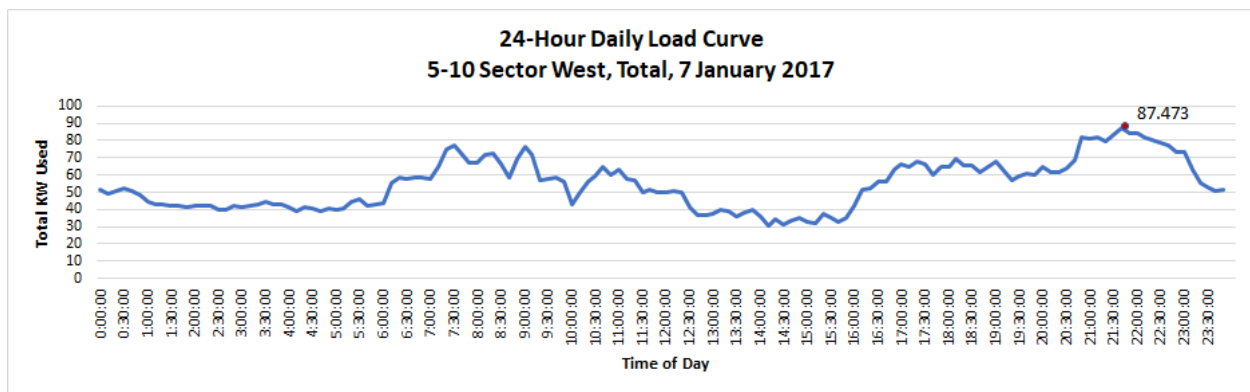


LOG 114

Tags: Workshop, Accommodations, Ablutions



CAMP TOTALS



Sector West 5-66

No Ablutions listed, besides 4 toilets

LOG Collection Tags (labels for intercamp comparison)

Officer & Regular Accommodations

Post Exchange

Hospital

ESS Workshop

ESS Offices

Gate Entrance

Shelter

Deep Well Pump

Kitchen

Given 4 toilets across all sectors recorded by LOG sheets, estimated camp size is 50 people.

On Jan. 20, 2017, the per capita maximum energy consumption was 90.801 KW.

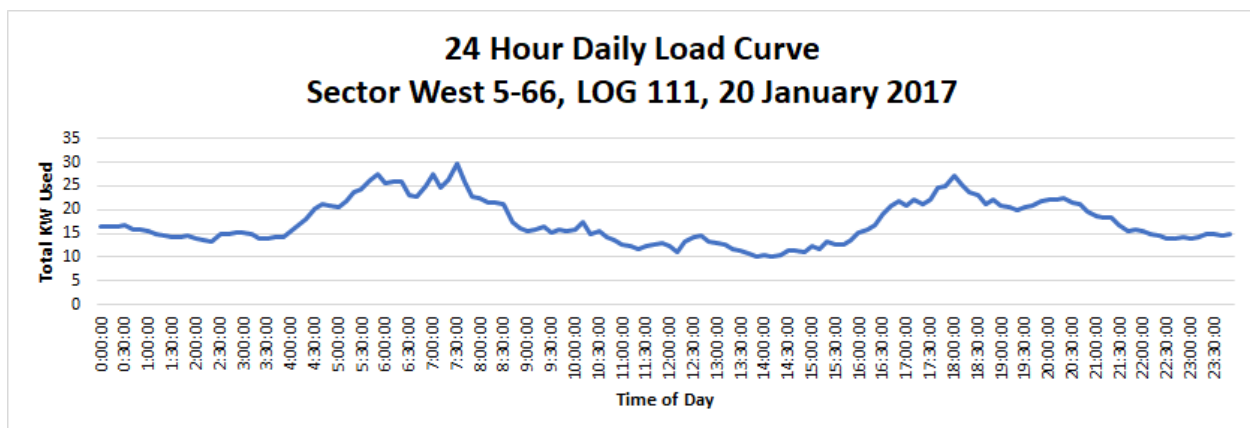
From approx. 7:00 until 16:45, the total energy usage in the camp did not exceed 90.801 KW.

Recommendations:

1. 1 x 500 KVA generator is sufficient to supply camp during peak hours.
2. 2 x 500 KVA generators could be permanently turned off.
3. 1 X 135 KVA generator would also be sufficient to supply camp during peak hours.

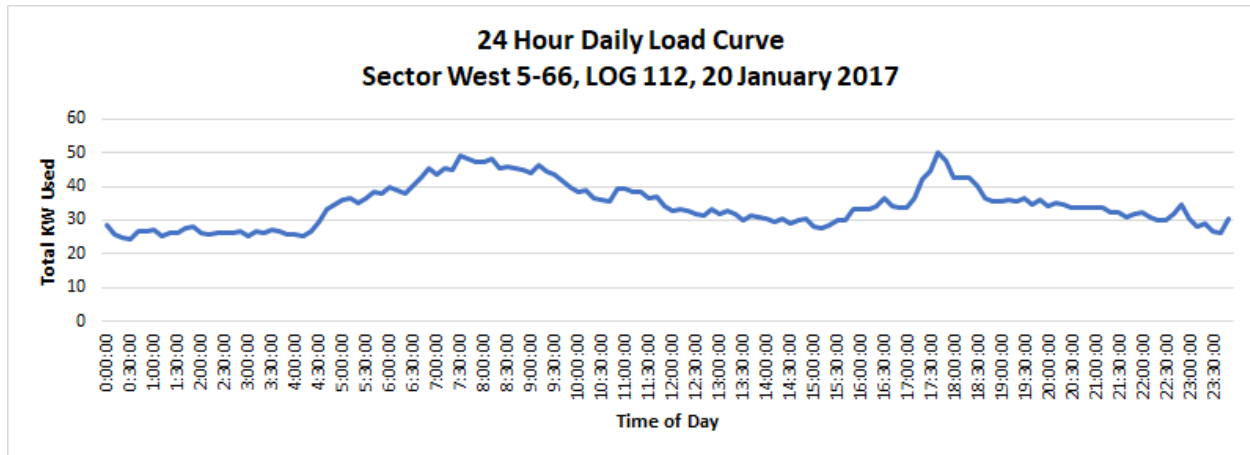
LOG 111

Tags: Hospital, Officer/Regular Accommodations, Post Exchange



LOG 112

Tags: ESS Workshop & Offices, Gate Entrance, Accommodations, Toilets, Shelter



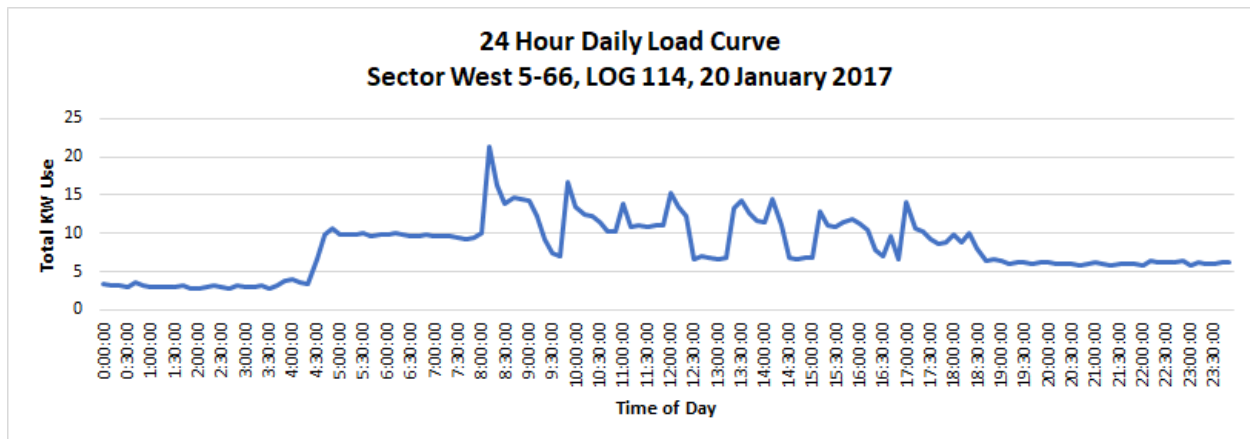
LOG 113

Tags: Deep Well Pump

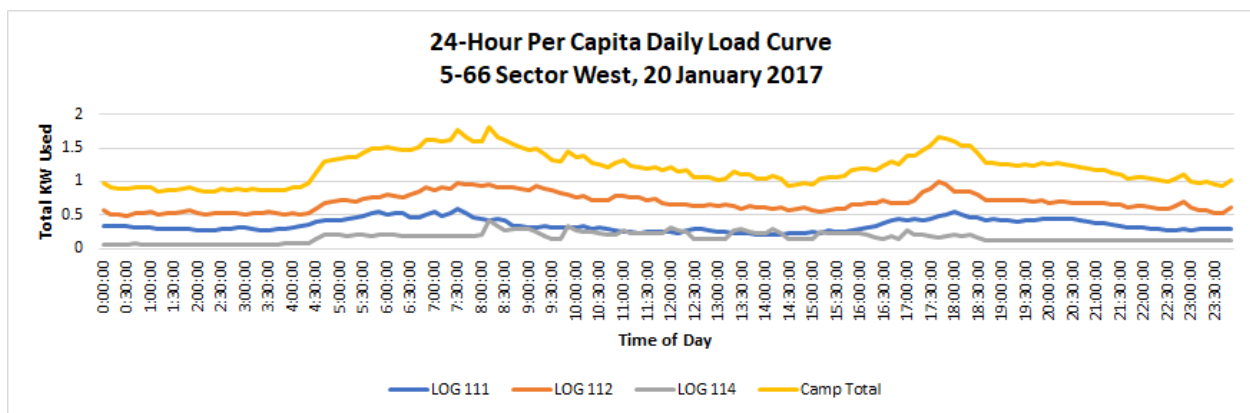
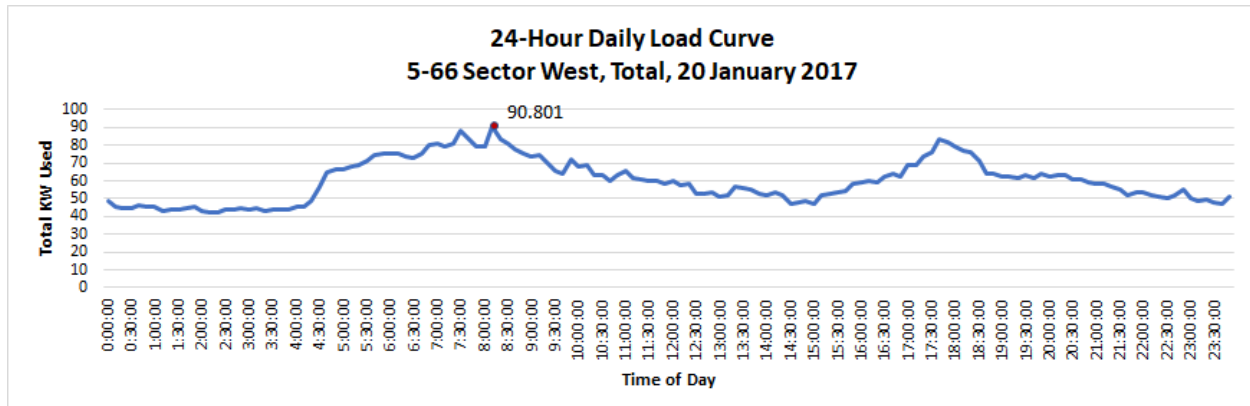
There is no 24 Hour time frame with Avg. KW 3 Phase Total data available

LOG 114

Tags: Kitchen, Freezers, Refrigerators



CAMP TOTALS



UNP 8-30 Sector East

Number of ablutions not listed, number of people not listed.

On Nov. 26, 2016, the maximum energy consumption was 137.5 KW.

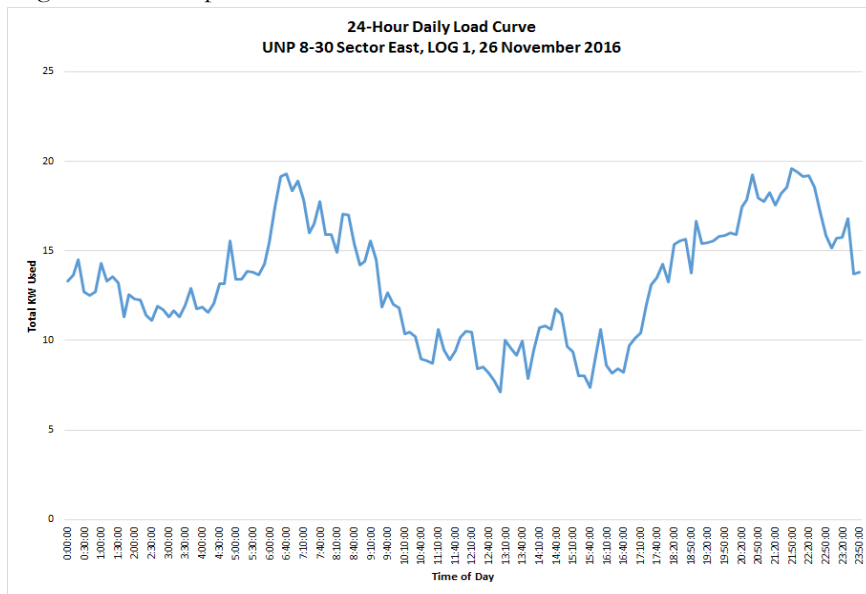
Except from approx. 5:00 to 7:00, the total energy usage in the camp did not exceed 135 KW.

Recommendations:

4. 1 X 135 KVA generator is sufficient to supply camp for all hours of the day except 5:00-7:00.
5. 2 X 80 KVA, 1 X 135 KVA, 1 X 45 KVA, 1 X 62.5 generators could be permanently turned off.
6. 1 X 135 KVA generator would also be sufficient to supply camp during slow hours.

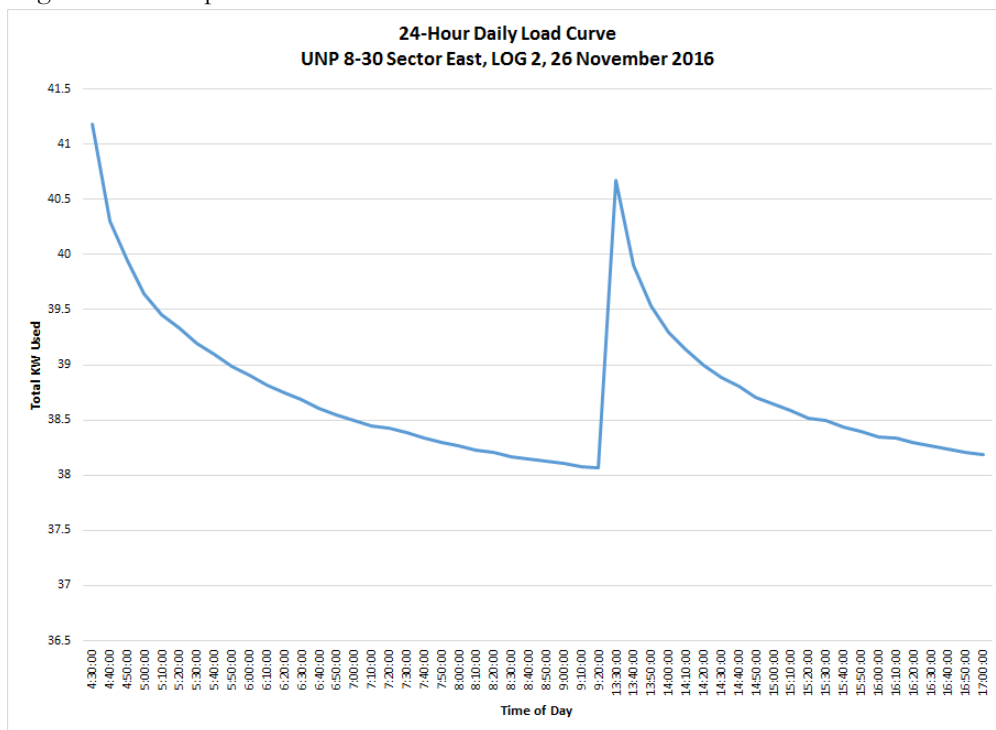
LOG 1

Tags: Water Pump, others unknown



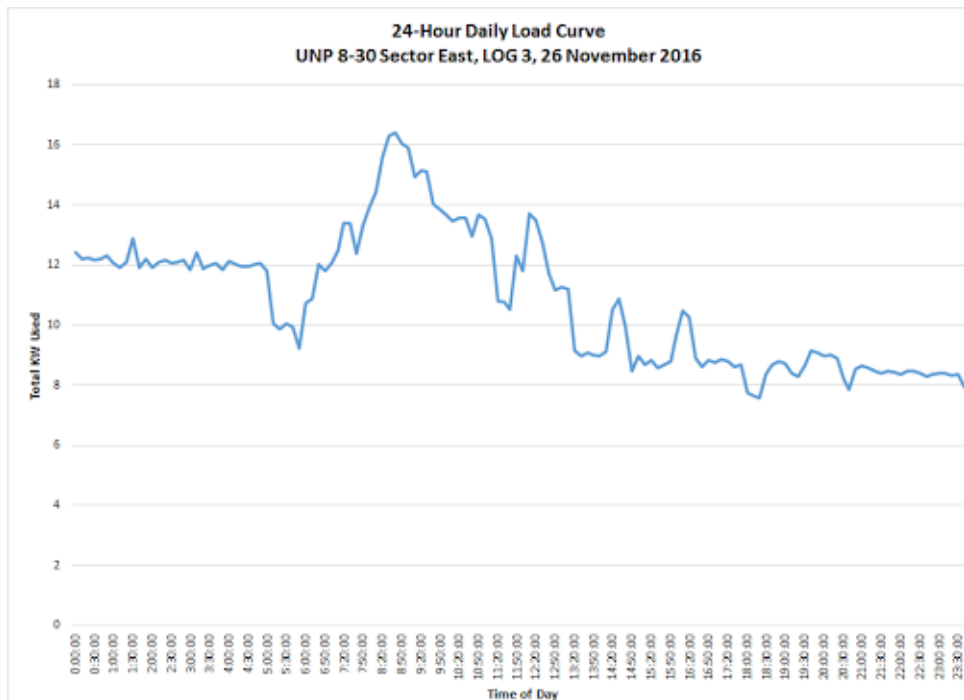
LOG 2

Tags: Water Pump



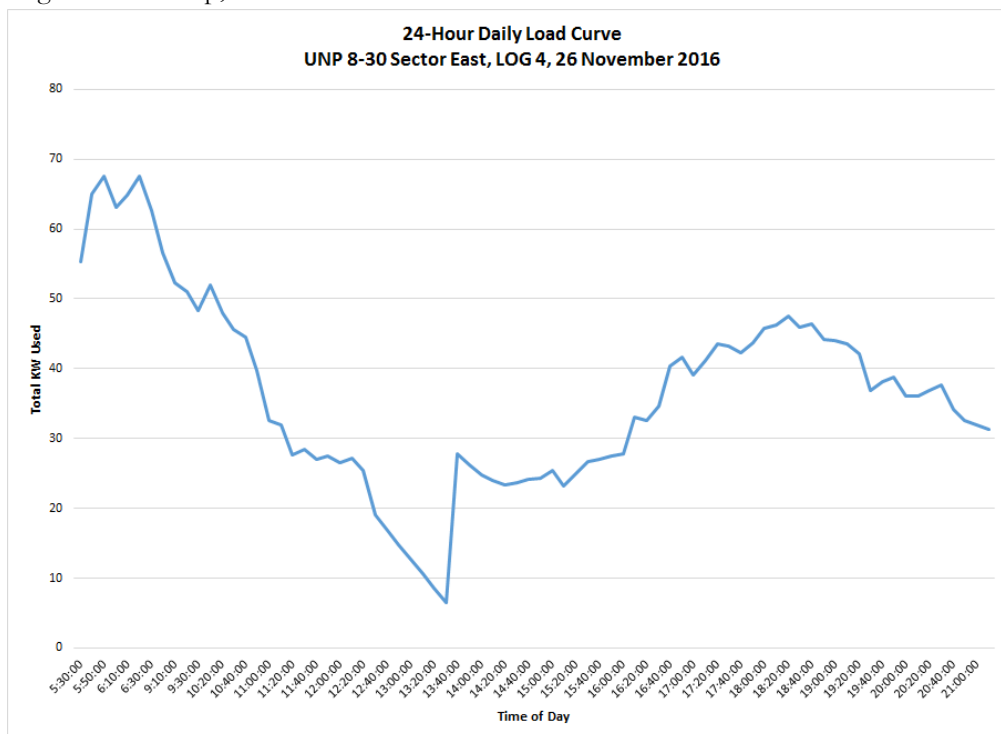
LOG 3

Tags: Kitchen, Hospital, Water Pump

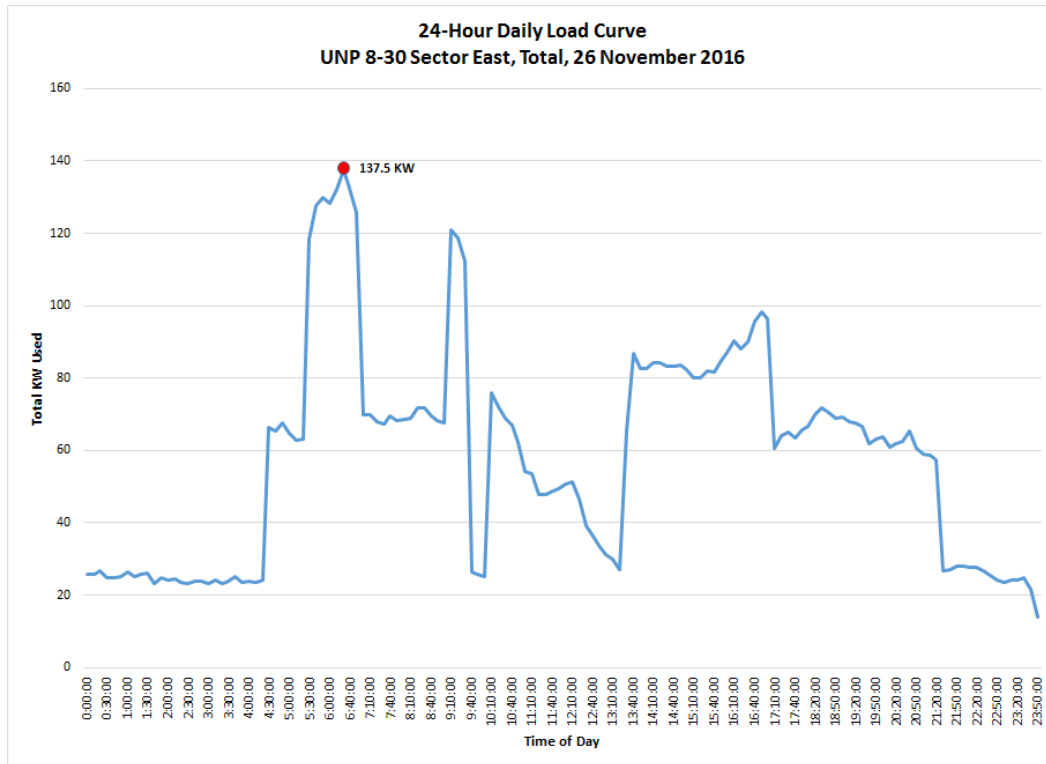


LOG 4

Tags: Water Pump, others unknown



CAMP TOTALS



Daily Per Capita graph not presented here, because data provided does not enable an estimate of camp population.

SECTOR WEST 1-0A

Number of ablutions not given, document lists 230 people.

On Dec. 23, 2016, the per capita maximum energy consumption was 0.341 KW.

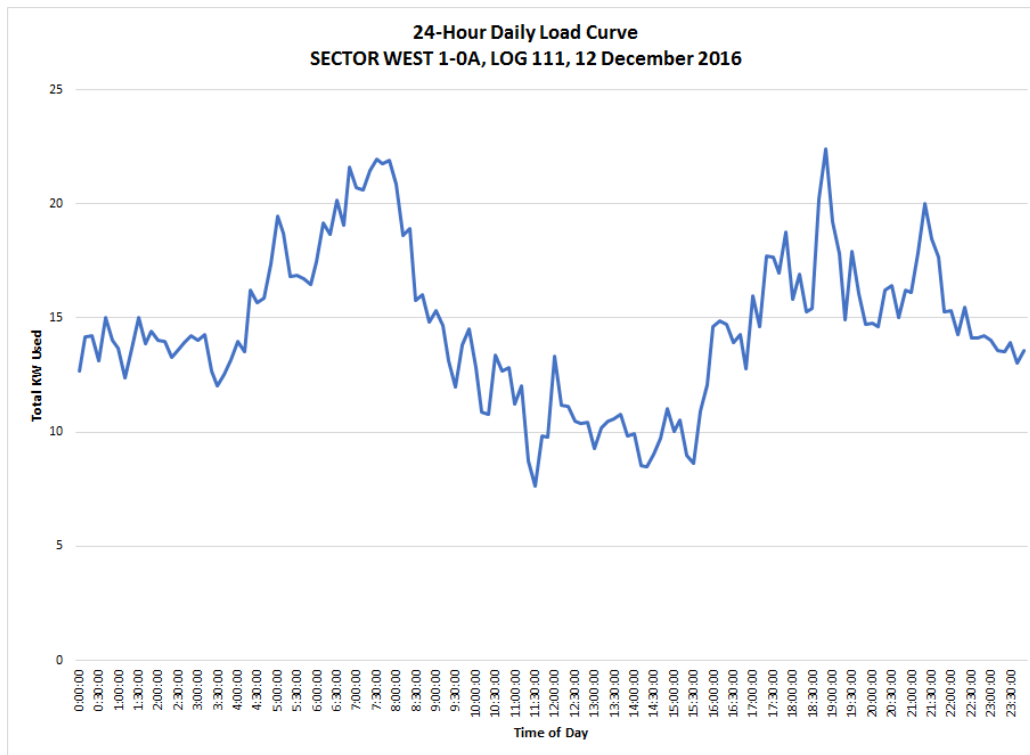
Except from 17:00 until 19:30, the total energy usage in the camp did not exceed 80 KW.

Recommendations:

4. 1 X 250 KVA generator is sufficient to supply camp for all hours of the day.
5. 2 X 250 KVA generators could be permanently turned off.
6. 1 X 80 KVA generator would also be sufficient to supply camp during slow hours.

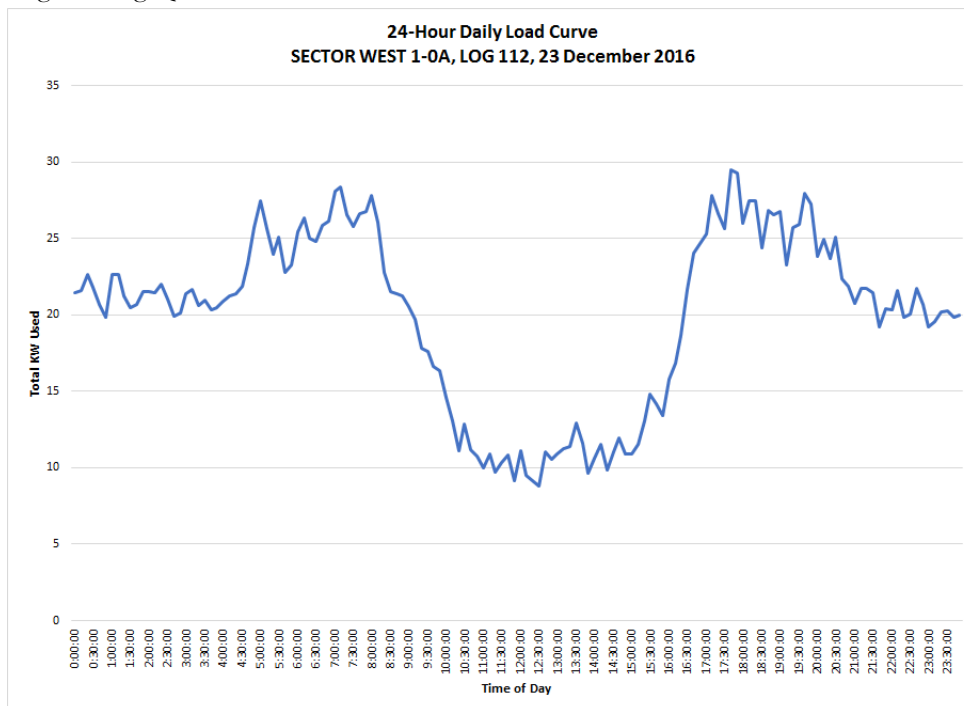
LOG 111

Tags: Kitchen, Living Quarters



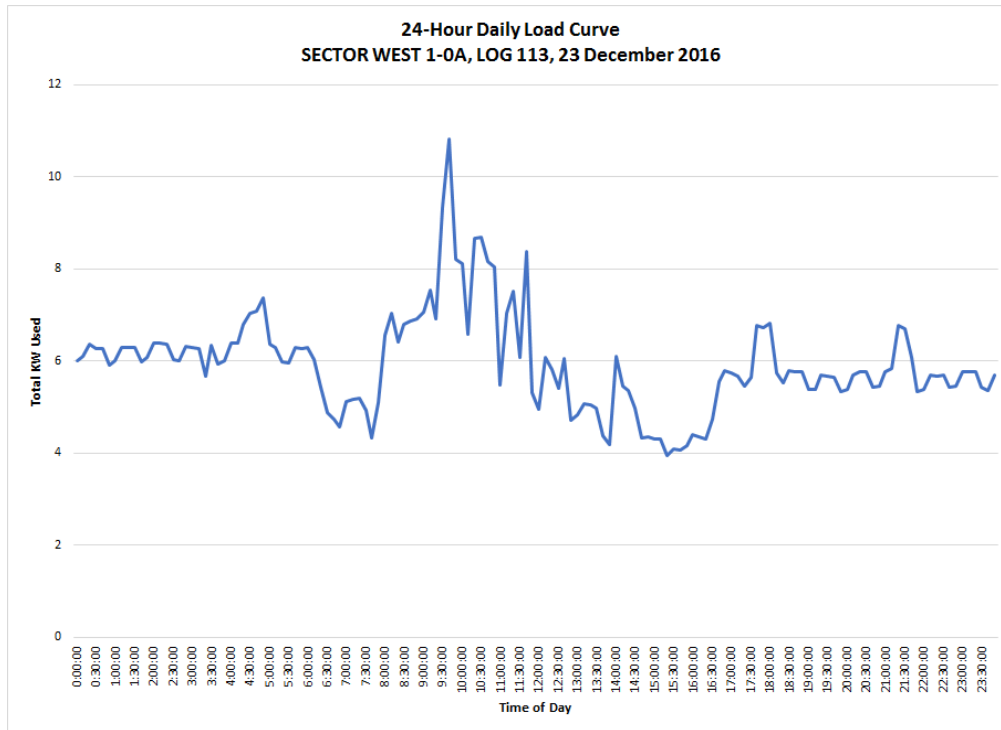
LOG 112

Tags: Living Quarters



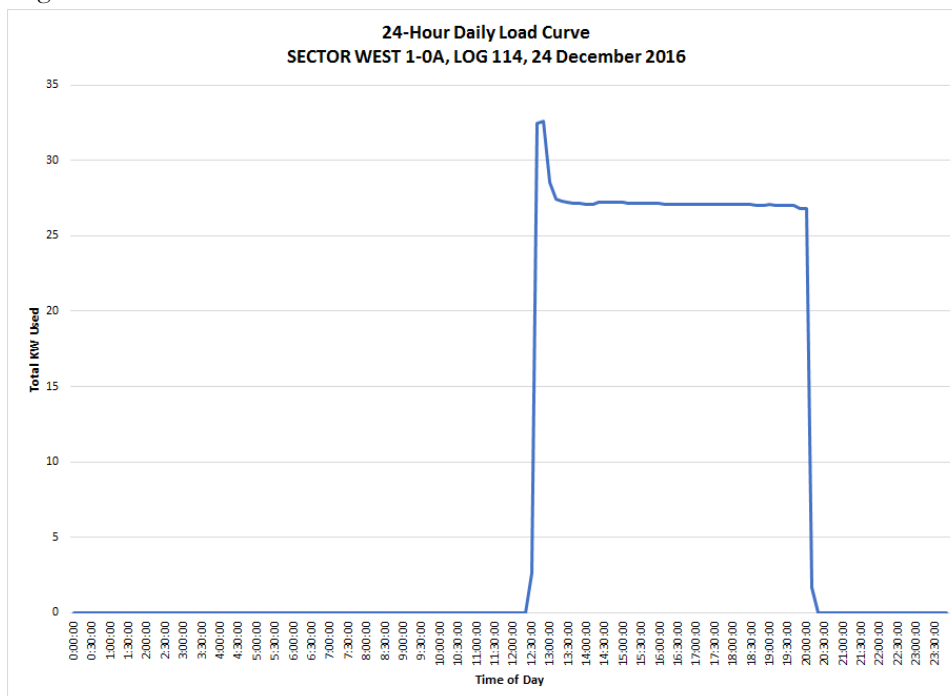
LOG 113

Tags: Water Pump

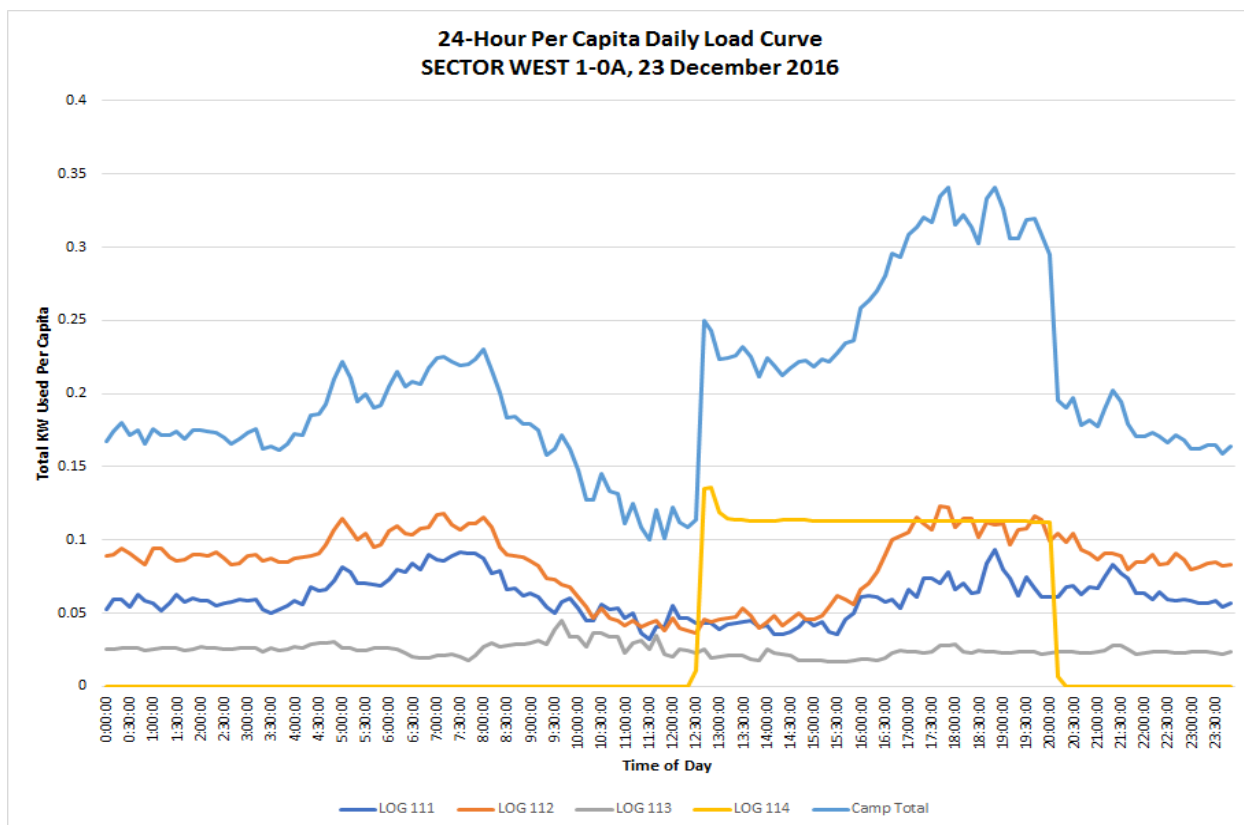
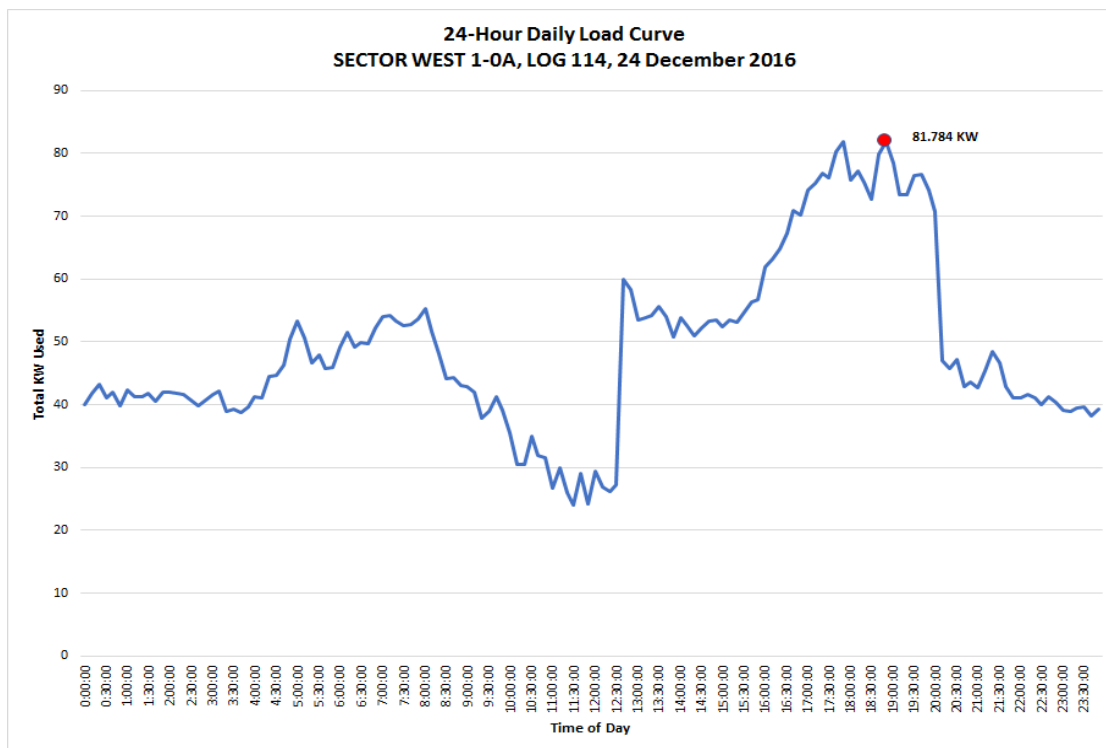


LOG 114

Tags: Kitchen



CAMP TOTALS



Appendix B

Breakdown of Overall Process Flowchart

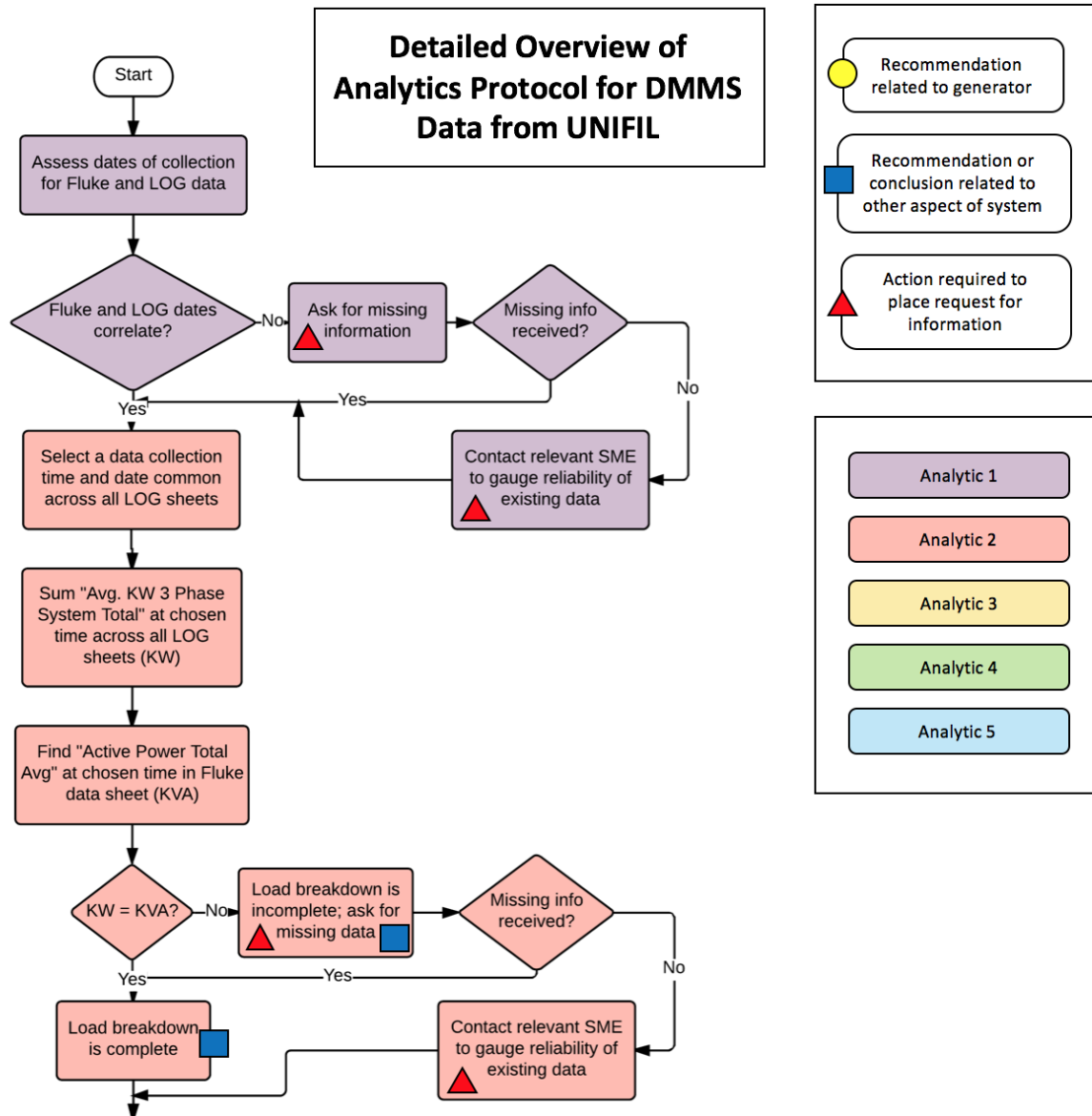


Figure B1: Top segment (1/3) of detailed logic flow of Analytics 1-5 for DMMS analysis

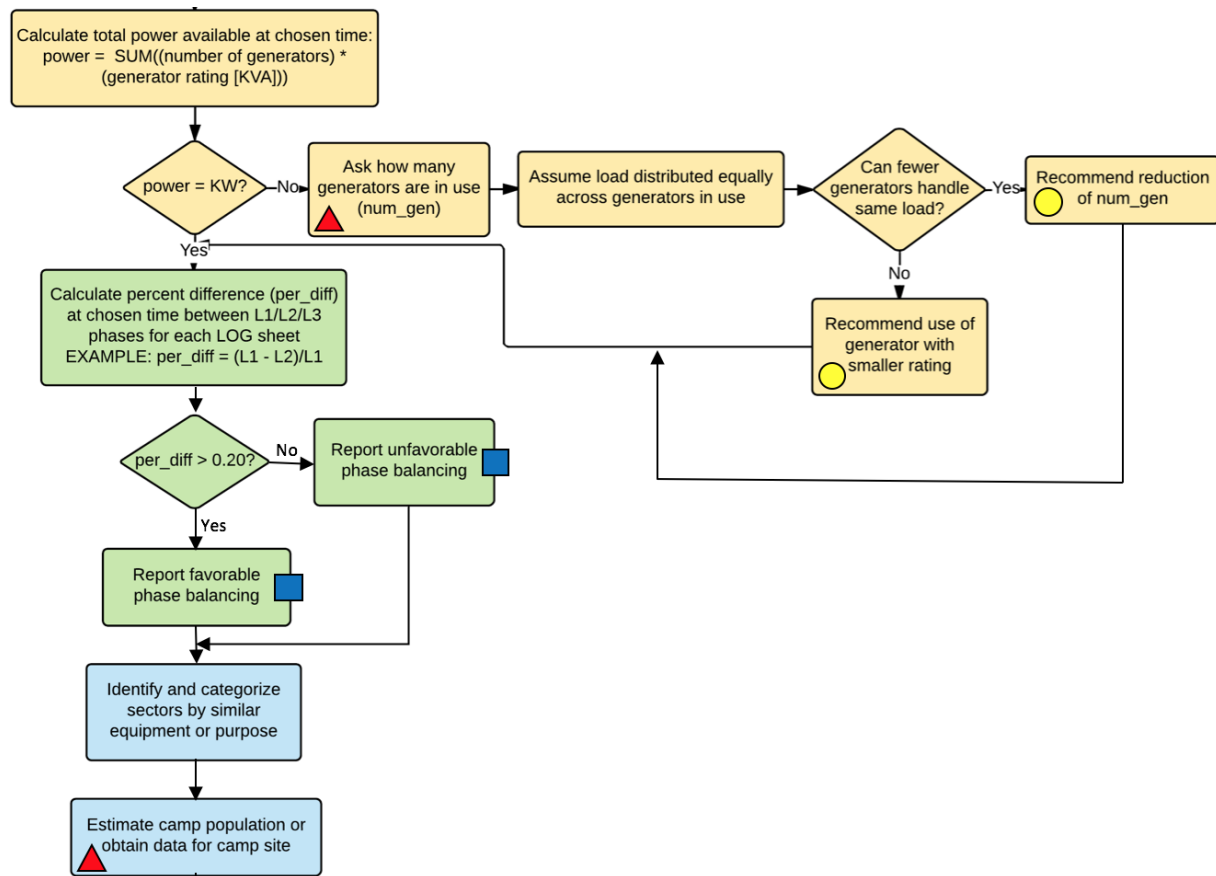


Figure B2: Middle segment (2/3) of detailed logic flow of Analytics 1-5 for DMMS analysis

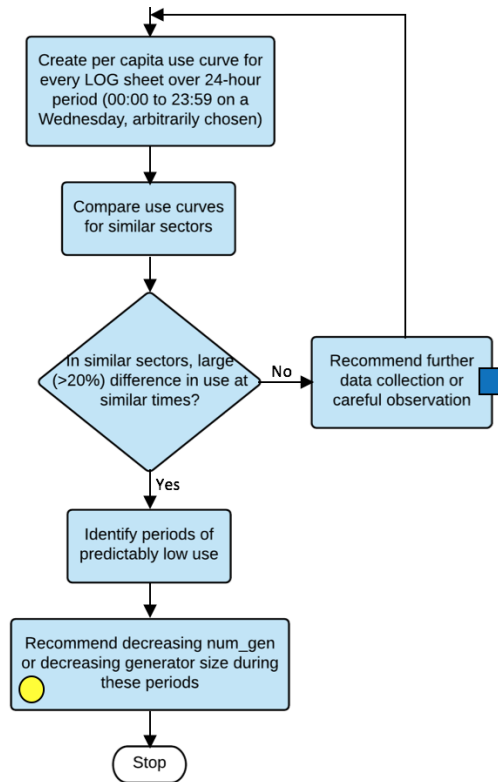


Figure B3: Bottom segment (3/3) of detailed logic flow of Analytics 1-5 for DMMS analysis

References

Listed are recommended positions of SMEs who are affiliated with the collection of raw, DMMS data and process analysis.

- **Tom Decker** – Expeditionary Energy and Basing SME - Operational Energy Program Manager, U.S. Army Corps of Engineers Construction Engineering Research Laboratory
- **Elias Farah** – UNIFIL Electrical Unit - Lead of Installation of Recorders and Data Collection
- **Philip Kerr** – Electrical/HVAC Unit
- **Andrew Morton** – Energy and Engineering Program Manager
- **Julie Sapp** – Expert Consultant
- **Rich Weichsler** – Expeditionary Energy and Basing SME - Deputy Operational Energy Program Manager, U.S. Army Corps of Engineers Construction Engineering Research Laboratory

Notes

1. “Peacekeeping Fact Sheet,” *United Nations Peacekeeping*, 31 July 2017, <<http://www.un.org/en/peacekeeping/resources/statistics/factsheet.shtml#IFIL>>.
2. “Sustain the Mission Project: Resource Costing and Cost-Benefit Analysis,” *Army Environmental Policy Institute*, 2006. <<http://www.aepi.army.mil/publications/sustainability/docs/sustain-mission-rcosting.pdf>>.
3. Diesel Service & Supply, “Approximate Diesel Generator Fuel Consumption Chart,” 2017, available at <http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx>.
4. IPT Fuel Prices, August 2017, available at <<http://www.iptgroup.com.lb/ipt/en/our-stations/fuel-prices>>.
5. Tom Decker (Operational Energy Program Manager from the U.S. Army Corps of Engineers Construction Engineering Research Laboratory) in discussion with the authors, July 2017.

