

Standard Operating Procedure

FMOM-Operations & Building Management

9 November 2020

Energy Review Methodology

OBM-CSBM-SOP-007-(1)

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Revision History

Version Number	Effective Date	Changes Description
000	11 Sep 2019	First version
001	9 Nov 2021	Second version

1. Purpose:

The purpose of this Standard Operating Procedure is to support the Building Management team members in the energy review activities of investigating, measuring and identifying reasons behind significant increase or decrease in energy consumption of KAUST facilities. The review is triggered upon increase/decrease in consumption of $\pm 5\%$ in the month being reviewed compared to the same month in the year before, and/or the previous month. This report compliments and must be read in conjunction with CTPS-0074 SOP.

2. Scope:

All Campus and Technology Park buildings, and other KAUST facilities with power meter and energy data available.

3. Definitions:

ACH	Air Change per Hour
AHU	Air Handling Unit
BAS	Building Automation System
BMT	Building Management Team
CHWP	Chilled Water Pump
CRF	Change Request Form
CSBME	Customer Service & Building Management Engineer
DP	Distribution Panel
EAV	Exhaust Air Valve
FCU	Fan Coil Unit
HVAC	Heating, Ventilation and Air Conditioning
IKAS	Integrated KAUST Automation System
ICR	Installation and Completion Report
L	Lighting Panel
PH	HVAC Panel
PL	Lab Panel
PMS	Power Monitoring System
PPM	Planned Preventive Maintenance
PR	Receptacle Panel
SAV	Supply Air Valve
SOP	Standard Operating Procedure
US	Unit Substation
VAV	Variable Air Valve
WICF	Work

4. Responsibilities:

- 4.1. Customer Service and Building Engineer: adhere to the procedure outlined herein and raise issues/continuous improvement.
- 4.2. Buildings Management Lead: ensures Standard Operating Procedure is reviewed and updated. Adhere to the procedure outlined herein and record issues/continuous improvement comments from Building Liaison Engineer.
- 4.3. Building Operations Lead: ensures the provision of data, technical support, and engineering consultation related to the energy review.
- 4.4. Energy Coordinator: a member from the Building Operations Team, and the person in charge of the KAUST Energy Saving Program.

- 4.5. FM O&M Operations Manager: ensure defining and findings applied on timely manner, in addition to the success of the energy review as part of the Energy Saving Program.

5. Procedures:

Identifying the Applicability for a Review:

Energy Dashboard will be emailed to the Building Management Team through the Energy Coordinator from the Building Operations Team, indicating increase/decrease of all campus buildings consumption. The dashboard is normally sent out at the beginning of every month for the previous one.

The CSBE will review the increase/decrease of energy consumption from the Monthly Energy Dashboard, and evaluate if a review is required for the assigned facilities by considering #5% of consumption in the month of review compared to the same month from the year before, and/or the previous month (i.e., if July 2019 consumption was $\pm 5\%$ compared to July 2018 and/or June 2019, then a review is needed).

Target of the Review

The Review will target the development of the following items as per the #5% change in consumption:

5.1. If +5% of increase is recorded:

- 5.1.1. Identifying source of increase (i.e., new receptacles or projects installations).
- 5.1.2. Controlling the parameters that led to the increase (i.e., set points modifications).
- 5.1.3. If the increase cannot be controlled, understanding the controls need to be discussed with the management through the Building Management Lead with the positive outcomes to share it with the team for knowledge sharing.
- 5.1.4. Present the outcomes during the daily operations morning meeting if necessary (subjected to Building Management Lead's judgement) and via the approved "Lessons Learned" channels suggested by the "Energy Management System"

Collecting the Data Review

5.2. *Using IKAS:*

- 5.2.1. The CSBE can extract and compare the increase or decrease in consumption by:
- Accessing the main "Home Page" of IKAS.
 - Choosing the assigned building from the main map.
 - Clicking on "PMS",
 - Clicking on "Energy Calculation".
 - Setting the periods of comparison under "Period 1" and "Period 2".
 - Finally, taking all readings from the screen under "Period 1" and "Period 2"

Additional data can be extracted from the trend symbols next to the consumption on the right. All the achieved data in this step are in MWh. Now, the CSBE can identify the major components (HVAC, Lighting, Receptacles and Others in some buildings) that led for energy increase or decrease, and give more weight to components for zooming in further in the investigation. Under this step, the breakdown of data can be found under each period as shown in the figure below:

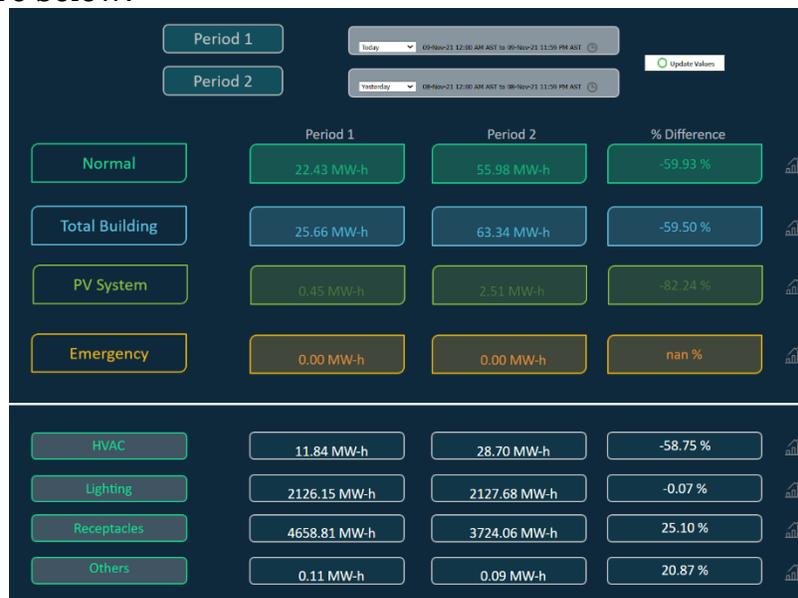


Figure 1: PMS Dashboard

- 5.2.1. **This step is an alternative option in case step a. falls in identifying the breakdown of the energy consumption due to technical difficulties.** Accessing:
- The main "Home Page" of IKAS.
 - Choosing the assigned building from the main map.
 - Clicking on "PMS"
 - Clicking on each of the breakdown components (HVAC, Lighting, Receptacles and Others in some buildings) individually, which will lead to a trend sheet.

- e. For each component, the trends need to be set under the desired time range, and the extracted data will be live (or history) in KW.
- f. Once the data in KW is collected, conversion to KWh is done by multiplying with the number of hours in that period (i.e., a month of 30 days has 720 hours, therefore if 100 KW is recorded, the total consumption in the period of 30 days will be = $(100 \times 720) \div 1000 \rightarrow 72$ MWh).
- g. Once each component consumption is calculated, the breakdown data are ready for use.
- h. Complete this step for both months of the review, and identify the delta (the difference in consumption) between both months for each component.
- i. Now, the CSBE can identify the major components that led for energy increase or decrease, and give more weight to components for zooming in further in the investigation.

5.3. Zooming into Electrical Panels (*Alternative Approach for Data Collection*):

The difference in terms of consumption for campus buildings can be identified with either an increase and/or decrease by comparing the unit substation readings between different months of comparison as the following:

- 5.3.1. The US that has an increase/decrease can then be the starting point of zooming into its distribution panels where each US has several feeders that feeds number of DPs (MCCs/PHs in some buildings).
- 5.3.2. Each DP will have its own reading (from the US feeder) feeding multiple panels and sub-panels (PH, PL, PR, L, etc.) which will also be compared by getting the trend (from IKAS) of the comparison months to identify the increase/decrease of all DPs.
- 5.3.3. Then, each CSBE will need to zoom into the panels and sub-panels that its own DP feeder has a significant increase/decrease comparing to other Ps. From those sub-panels, one or more sub-panels will explain the increase/decrease by checking the cumulative MWh trend (or the average KW trend of the live data) from IKAS.
- 5.3.4. That increase/decrease can be under further investigation to justify the reason/s behind that increase/decrease (i.e., events, undergoing projects, additional load on sub-panels, etc.)

Zooming into Components:

5.4. *Airflow and AHU Consumption Calculations*: Using IKAS, the BLE can extract and compare the increase or decrease in consumption by:

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- 5.4.1. The he BLEs will identify the total increase of airflow in L/s, in addition to the extended support of Building Operations Team whenever a major change in building systems are implemented. This step can be done through extracted data from IKAS.
 - 5.4.2. Once the sum of total increase or decrease in airflow is identified, the total value can be multiplied with the Wh factor for each 1 L/s of airflow. To calculate the irregular (increased or decreased) airflow per hour by, the "Energy Calculation for Air Flow Unit" Excel sheet provided by the Building Operations Team can be used for quantification.
- 5.5. Chilled Water Pumps: Using IKAS, the BLE can extract and compare the increase or decrease in consumption by:
- 5.5.1. The main "Home Page" of IKAS.
 - 5.5.2. Choosing the assigned building from the main map
 - 5.5.3. Clicking on "BAS".
 - 5.5.4. Clicking "Chilled Water Pump (0.00X)".
 - 5.5.5. Clicking on the total cumulative consumption for all the pumps (multiple pumps in most buildings under each pump room), which is indicated in a numerical value next to "kW-hr"
 - 5.5.6. Trend the period of time desired for comparison (i.e., 1st - 31st July 2018).
 - 5.5.7. Take the maximum value in the trend and subtract from it the minimum value in the trend. The resultant value would be the total consumption in MW for the period of time selected.
 - 5.5.8. Repeat the previous steps and identify the other month consumption, and now the total increase from chilled water pumps consumption can be calculated by taking the difference between both months' consumption.
 - 5.5.9. BLE can now revise changes in set points, flow, overridden points, etc. (refer to step number 13 in this procedure). with the engineers from Building Operations Team, in order to provide a reason behind the irregular consumption (i.e., higher cooling demand in the building).
- 5.6. Additional Load Schedule (ICR): Using the ICR matrix that is to be provided by Building Operations Team through the Energy Coordinator on monthly basis, the BLEs will identify the additional increase in Campus consumption through the following steps:
- 5.6.1. The CSBE will access the Additional Load Tracking sheet.
 - 5.6.2. Filter the building that needs to be reviewed.
 - 5.6.3. Identify all additional loads in the month of review under "Operation Date CTPS"
 - 5.6.4. Calculating the sum of all additional loads by adding all the numbers for new loads of the period under "Capacity KW"

5.6.5. By summing all the additional loads capacity in KW, the BLEs can multiply the total by the period of time of which the loads were operational; and then the additional load can be identified in MWh.

5.7. *HVAC Panels and Lab Billing Statements:* Building Operations Team extends their support to the Building Management team through providing access to all BLEs for Lab Energy Statements, in addition to HVAC panels consumption for Campus Buildings for the month of review, compared to the same month from previous year and/or the previous month. The BLEs will:

5.7.1. The Identify the top 20% consuming HVAC panels in KW from the column of "average" under each period of time (20-80 rule).

5.7.2. Take the difference between the months of comparison for the top 20% of HVAC panels. The difference will be in KW.

5.7.3. Multiply each value under difference with the number of hours in period of comparison to achieve the unit KWh or MWh.

5.7.4. Now the BLEs will have the total increase/decrease in MW for the top consuming HVAC panels, and can zoom in further by prioritizing highest consuming panels. In case the total increase vs. the total decrease does not indicate an increase in energy consumption, this method can be stopped, where no increase in HVAC panels' consumption is found. BLE need to obtain the load schedules from the Technical Library through the following link:

<https://kaust.sharepoint.com/sites/fc-facilities/it/Technical%20Library%20Request/Lists/Technical%20Library%20Request%20for%20Information%20Form/Item/newifs.aspx?List=2a3f6fee-0df2-4e4a-a5e7-f3e492e93a20&Source=https%3A%2F%2Fkaust%2Esharepoint%2Ecom%2Fsites%2Ffc-facilities%2Fit%2FTechnical%2520Library%2520Request%2FLists%2FTechnical%2520Library%2520Request%2520for%2520Information%2520Form%2FAllItems%2Easpx&ContentTypeId=0x0100C48F7C19B7C9F443972B4269A618F7EA&RootFolder=%2Fsites%2Ffc-facilities%2Fit%2FTechnical%20Library%20Request%2FLists%2FTechnical%20Library%20Request%20for%20Information%20Form>

5.7.5. From load schedules, each device needs to be identified in IKAS, if feasible, or other sources in order to check the trends of their consumption historically, and once the areas of irregular consumptions are identified; the BLEs can interview end users, investigate and control the parameters led to the irregular consumption.

5.7.6. If the load schedule points towards devices supplying labs, the Lab Billing Statement can be referred to in order to monitor irregular consumption. The BLEs can access the Lab Billing Statement through:

- a. The main "Home Page" of IKAS.
 - b. Clicking on "Overview" from sidebar.
 - c. Clicking on "Lab Energy Dashboard"
 - d. Choosing the assigned building.
 - e. Reviewing desired lab statements by clicking on lab number.
 - f. Reviewing consumption of labs based on year and month.
- 5.7.7. After reviewing Lab Billing Statements, BLEs will discuss with Lab Managers or Representatives
- a. Any extra working hours.
 - b. Additional loads (outside E&PM scope).
 - c. Special activities that could lead to higher consumption in energy.
 - d. The possibility of enhancing the occupancy schedule.
 - e. **Note: prior to engaging with the client, the BLE must obtain all relevant schedules and operating parameters of the lab in question, in order to be prepared for such meeting.**
- 5.7.8. Lighting panels within lab space can be investigated to further understand if bugs or issues in the lab schedules are present. As lighting is connected to HVAC in all lab spaces of Campus, BLEs can identify any irregular trends from the Panel Trends in IKAS under:
- a. The main "Home Page" of IKAS.
 - b. Choosing the assigned building from the main map.
 - c. Clicking on "PMS"
 - d. Clicking on "Power Lab".
 - e. Browsing desired lighting panel.
- 5.7.9. After identifying irregular increases in lighting trends, CSBEs can investigate reasons behind the increase and relate the increase in relevant HVAC panels to the lighting panel.
- 5.7.10. From each device (i.e., SAVs, VAVs, etc.) CSBEs can identify them in IKAS and quantify the consumption through cumulative or instant consumption.
- 5.7.11. Summing all increases in MWh will provide the total increase between both months of comparison.
- 5.8. *Lighting Schedules and Panel Consumption:* Building Operations Team extends their support to the Building Management team through providing the CSBEs with lighting panels consumption for Campus Buildings for the month of review, compared to the same month from previous year and/or the previous month. The CSBEs will:
- 5.8.1. The Identify the top 20% consuming lighting panels in KW from the column of "average" under each period of time.
 - 5.8.2. Take the difference between the months of comparison for the top 20% of lighting panels. The difference will be in KW.

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- 5.8.3. Multiply each value under difference with the number of hours in the period of comparison to achieve the unit KWh or MWh.
 - 5.8.4. Now the CSBEs will have the total increase/decrease in MWh for the top consuming lighting panels, and can zoom in further by prioritizing highest consuming panels.
 - 5.8.5. CSBE need to obtain the load schedules from the Technical Library.
 - 5.8.6. From load schedules, each device needs to be identified in IKAS, if feasible, or other sources in order to check the trends of their consumption historically, and once the areas of irregular consumptions are identified; the CSBEs can interview, investigate and control the parameters led to the irregular consumption.
 - 5.8.7. If the load schedule points towards devices supplying labs, the CSBE will refer to step number lab billing previous steps of this procedure.
 - 5.8.8. The CSBE will identify the locations where the light is in office spaces, atriums, auditoriums, external lights, etc. and will coordinate with the Shift Operation team to revise the schedule for the area.
 - 5.8.9. If the schedule can be modified, the CSBE will route a CRF for modification.
 - 5.8.10. If the technical change/difficulty in modifying the schedule comes from Lutron system, the CSBE will contact the Electrical Team Lead for extended support.
 - 5.8.11. Once the control parameters are troubleshoot, the CSBE can quantify the consumption before and after modification by referring to number of operational hours for lighting in the area before and after the change.
 - 5.8.12. It is important to add the countdown command in the CRF for returning rooms into energy saving schedule, and considering human factor (overriding the schedule through switch button) during the calculations.
- 5.9. ACH: The CSBEs will be responsible to track and evaluate the potential increase/decrease in energy consumption in case a new lab space is occupied, or an older one become unoccupied:
- 5.9.1. The Building Management team will receive the occupancy request from Research Safety Team and place labs into occupied/unoccupied mode in collaboration with Research Safety as per the
 - 5.9.2. Laboratory Ventilation Management Program (LVMP) guidelines.
 - 5.9.3. Within 48h of the change in occupancy mode, the CSBE will check the performance of SAVs, EAVs and heaters as well as occupancy status via LCS on IKAS to ensure changes put in place are in operation
 - 5.9.4. The CSBEs will use the energy calculation for airflow unit that is provided by the Building Operations

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- 5.9.5. Team to quantify the increase/decrease in energy consumption due to ACH
- 5.9.6. Once quantified in MWh, the increase or decrease can be justified since the day of occupancy until further changes occur.
- 5.9.7. Any reductions in ACH in operating labs will follow the Laboratory Ventilation Management Program.
- 5.10. Events: The Event Design and Planning Specialist at CTPS emails out information on event dates and times on regular basis to CTPS workers. Monitoring and recording the history of events will help in quantifying energy consumption by the Operations Team:
- 5.10.1. The Energy Coordinator records the events in a matrix on monthly basis. Building Management team can refer to the matrix with the support of the Energy Coordinator to refer back to the history of events on Campus. The matrix will be shared between all Operations divisions on SharePoint system for reference.
- 5.10.2. MACC Electrical team will email the weekly building consumption matrix to the Operations Team normally at the beginning of each week, with the data of the previous week.
- 5.10.3. The Energy Coordinator will extend support to Building Management by emailing the collected data on a matrix for all days of the month (same matrix used to construct the energy dashboard) for further analysis.
- 5.10.4. The CSBEs will zoom into the data by referring to the dates with events and dates where no events were carried in the buildings.
- 5.10.5. CSBEs will average the consumption of energy throughout the month into two categories, "days with events" and "days without events".
- 5.10.6. Now the difference in consumption increases where events took place compared to days without events can be calculated by taking the difference between "days with events" and "days without events".
- 5.10.7. The total increase in KWh or MWh can be used as an average for all days with events, and can be summed up as total consumption due to events at the month of review.
- 5.11. Other Parameters to Consider: Collaboration between Building Management and Building Operations in identifying the following points on regular basis can support in understanding the behavior of energy consumption by routing CRFs for some of the applied changes below:
- 5.11.1. **Scheduling**: lab lighting, HVAC, heaters, etc.
- 5.11.2. **Overridden points**: VAVs, FCUs and CHWP (BAS system), off coil temperature, duct static pressure, etc.

- 5.11.3. **Outside temperature** (i.e., average of temperature in month of review for 2018 Vs. 2019)
- 5.11.4. **Outside humidity**
- 5.11.5. **PPMs** (i.e., reduction in consumption due to shutdown)
- 5.11.6. **Projects:** testing, additional loads on panels, or new panels (i.e., 24/7 testing).
- 5.11.7. **Other parameters:** activities the CSBE could identify from WCICs received throughout the month can be highlighted for further zooming in.