

# K-12 Energy Benchmarking Project

## Equipment Guide

Equipment	Lesson(s) Used
Ballast Checker (1)	Lighting Systems Audit
Data Loggers: Motor On/Off (1) Occupancy/Light (2) Plug Load (1) Temperature/%RH (1)	Building Envelope Audit Lighting Systems Audit Electrical Appliances Audit Building Envelope Audit
Infrared Camera (1)	Building Envelope Audit
Measuring Devices: Measuring Wheel (1) Range Finder (1) Tape Measurer (1)	All - Building Envelope Audit
Omega 4-in-1: (1) Light Meter Thermometer	Lighting Systems Audit Building Envelope Audit
Watt Meter (1)	Electrical Appliances Audit

This guide provides specific information on how to use energy auditing equipment with the Benchmarking Tool Spreadsheet and Benchmarking Lessons. For all equipment, you can find more information like user manuals, product websites, videos, etc. on our [Equipment Library page on our website.](#)



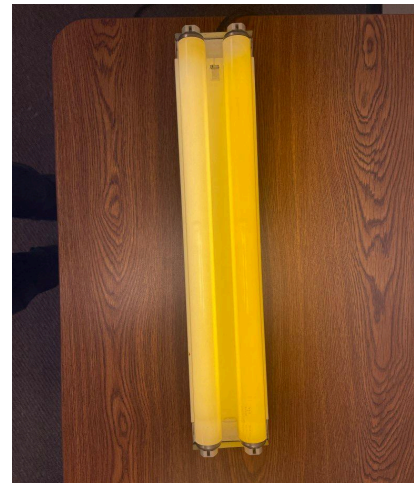
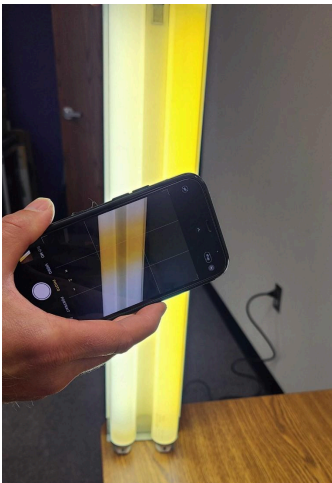
# Ballast Checker (Philips Advance Sensor Switch) [Lighting Systems Audit]



1. Point the checker at the light fixture. Press and hold the gray button. Note: The device can operate up to 15 feet and works only on fluorescent lamps.
2. If the light shows orange, that indicates the ballast of the fixture is magnetic. This ballast would be a candidate for updating to improve energy efficiency.
3. If the indicator light shows green, it is electronic, which is the newer and more efficient type of ballast.
4. Record “electronic” or “magnetic” in the K-12 Energy Benchmarking Project Tool Spreadsheet (lighting tab).

## Note:

If you don't have a ballast checker, you can also use the camera on your phone. If the ballast is magnetic, you will see yellow lines appear on your phone screen as you rotate your phone, while electronic ballasts will appear normal. See example photos below of how a magnetic ballast will appear.



# Data Loggers

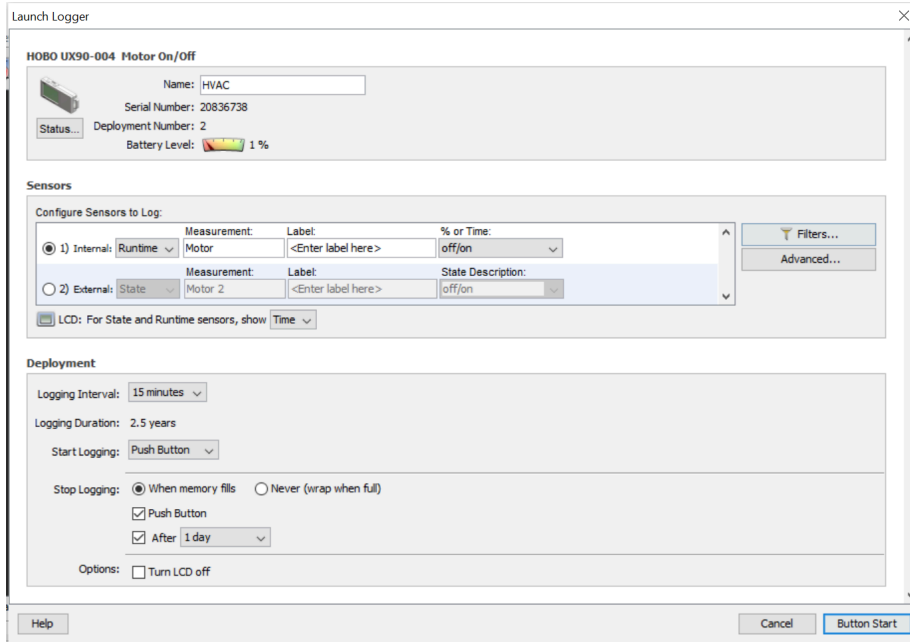
## Data Loggers I: Plan and Place Lesson

### How to Program HOBO motor on/off logger (Building Envelope Audit):

*Approximate time for downloading HOBOWare software program, programming loggers, and placing loggers: 1.5 -2 hours. We suggest downloading the HOBOWare software program prior to class starting (can take up to 1 hour to download).*

1. Using the USB cable, plug in your ONSET HOBO motor on/off logger. Download the free HOBOWare software (Windows or Mac): [www.onsetcomp.com/hoboware-free-download/](http://www.onsetcomp.com/hoboware-free-download/).
2. Once installed, click to open HOBOWare and follow the directions. You can choose the default settings; we will be using USB devices only.
3. Click Device>Launch>Enter Name (Example: HVAC). Most of the settings will stay as default. We use this type of data logger on the HVAC system or anything with a motor you want to monitor. When deciding the interval for data collection, avoid choosing one that is so brief you will end up with too many data points. For example, with a 1-minute interval, you will collect 1,440 data points in 24 hours! Depending on what equipment you are monitoring and for how long, consider programming the device for every 15 minutes in a 24-hour period, 30 minutes in a 48-hour period, or 1 hour in a 7-day period. When you download the data, each data point will tell you how long the motor was on or off during the interval. Ultimately, it's up to you and your students. You may want to run a short test with the data logger to see how the data looks before setting the device up for a longer period.
4. Adjust the "Start Logging" and "Stop Logging" to your preference. When ready, click "Start".



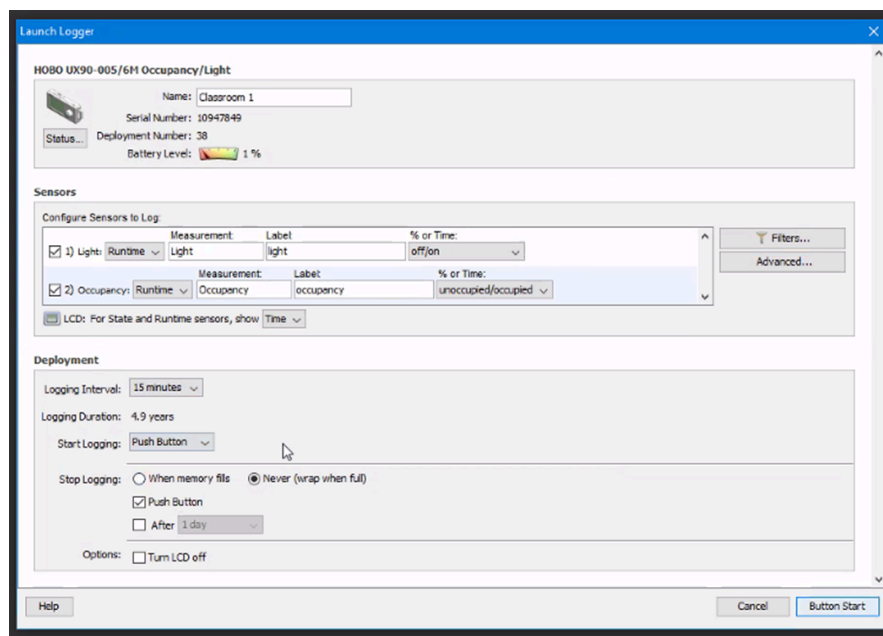


*This image is a screenshot of programming the occupancy/light logger in HOBOWare.*



## How to Program HOBO occupancy/ light logger (Lighting Systems Audit):

1. Using the USB cable, plug in the ONSET HOBO occupancy/light logger. If you haven't, download the HOBOWare software (Windows or Mac): [www.onsetcomp.com/hoboware-free-download/](http://www.onsetcomp.com/hoboware-free-download/)
2. Choose the room and time length you would like for each data logger. Remember to use the 5m (5 meters) data logger for smaller rooms and the 12m (12 meters) data logger for larger rooms. This is the distance from which the data logger can measure occupancy. There are magnets on the back of the data logger so that it can be placed on metal door jambs or other metal objects. People typically place them in any location that has lights that might be left on when unoccupied, such as classrooms, offices, gyms, or bathrooms.
3. Once the device is connected, in HOBOWare click Device > Launch. Name the room (Example: Classroom 1). Click on the light option and choose your logging interval (Example: 15 minutes). Everything else should be the default setting. When deciding the interval for data collection, avoid choosing one that is so brief you will end up with too many data points. For example, with a 1-minute interval, you will collect 1,440 data points in 24 hours! Depending on what room you are monitoring and for how long, consider programming the device for every 15 minutes in a 24-hour period, 30 minutes in a 48-hour period, or 1 hour in a 7-day period. When you download the data, each data point will tell you how long during the interval the lights were on and whether the space was occupied or not. You may want to run a short test with the data logger to see how the data looks before setting the device up for a longer period.
4. Adjust the "Start Logging" and "Stop Logging" to your preference. When ready, click "Start."
5. Repeat for all other occupancy/light data loggers.

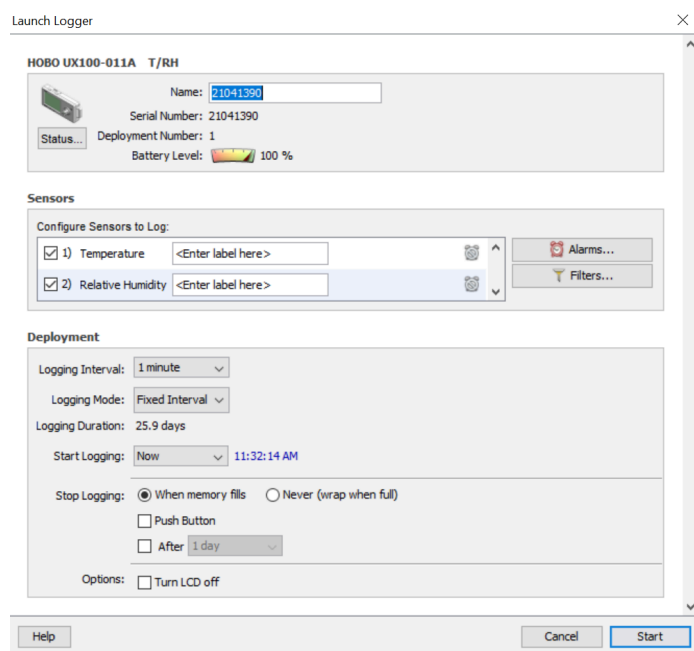


*This image is a screenshot of programming the occupancy/light logger in HOBOWare.*



## How to Program HOBO temperature/relative humidity (RH) logger (Building Envelope Audit):

1. Using the USB cable, plug in your ONSET HOBO temp/RH logger. If you haven't yet, download the HOBOWare software (Windows or Mac): [www.onsetcomp.com/hoboware-free-download/](http://www.onsetcomp.com/hoboware-free-download/).
2. Choose the location and time length of the logger. Typically we place the device in a classroom or office to compare with the thermostat. We like to see if the temperature and relative humidity are at an acceptable level.
3. Once it is connected to HOBOWare, click Device > Launch. Name the room (Example: Classroom 1). Choose your logging interval (Example: 15 minutes). Everything else should be the default setting. When deciding the interval for data collection, avoid choosing one that is so brief you will end up with too many data points. For example, with a 1-minute interval, you will collect 1,440 data points in 24 hours! Depending on location, consider programming the device for every 15 minutes in a 24-hour period, 30 minutes in a 48-hour period, or 1 hour in a 7-day period. You may want to run a short test with the data logger to see how the data looks before setting the device up for a longer period.
4. Adjust the "Start Logging" and "Stop Logging" to your preference. When ready, click "Start".

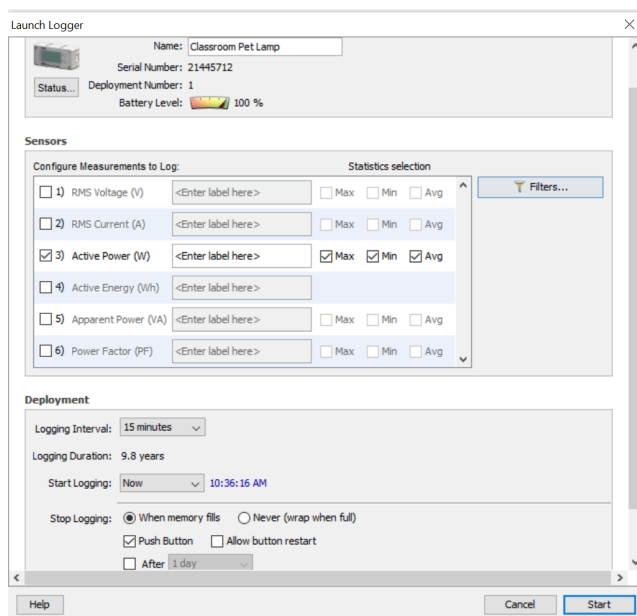


The image on the left is a screenshot of programming a temperature/RH logger. The image on the right shows what it looks like when it is on and collecting data.



## How to Program HOBO plug load data logger (Electrical Appliances Audit):

1. Using the USB cable, plug in your ONSET HOBO plug load logger. If you haven't yet, download the HOBOWare software (Windows or Mac): [www.onsetcomp.com/hoboware-free-download/](http://www.onsetcomp.com/hoboware-free-download/).
2. Choose the place and time length of the logger. You can use the device to monitor the energy consumption of AC-powered plug-in loads. Examples might be a coffee maker, copy machine, classroom pet lamps, etc.
3. Once it is connected, in HOBOWare click Device > Launch. Name the room or device (Example: Classroom Pet Light). Click on the measurements you want to log (example Active Energy (wh)). Choose your logging interval (Example: 1 hour).
4. Adjust the "Start Logging" and "Stop Logging" to your preference. When ready, click Start.



*The image on the left is a screenshot of programming a plug load logger for a classroom pet heat lamp.  
The image on the right shows what it looks like when it is on and collecting data.*



## HOBO Plug Load Data Logger as a Watt Meter [Electrical Appliances Audit]

1. Plug the data logger into an outlet.
2. Plug the device into the data logger.

Record the following data in the Benchmarking Tool spreadsheet:



Device is on and in use:

- Quantity of item
- Watts (W)
- Hours/day item is on

If the device is asleep or on standby:

- Watts (W)
- Hours/day item is on standby

Note:

Watt meters are useful for measuring energy or power consumption over brief periods or for devices that only have a simple on/off. Examples include hair dryers, blenders, etc. The Plug Load Data logger is used to collect data over a period of time, but could also be used as a watt meter. This type of data logger is useful for items that are likely to enter a sleep or standby mode such as monitors, computers, TVs, game systems, etc.

*This is an image of the plug load logger actively collecting energy data from a laptop.*





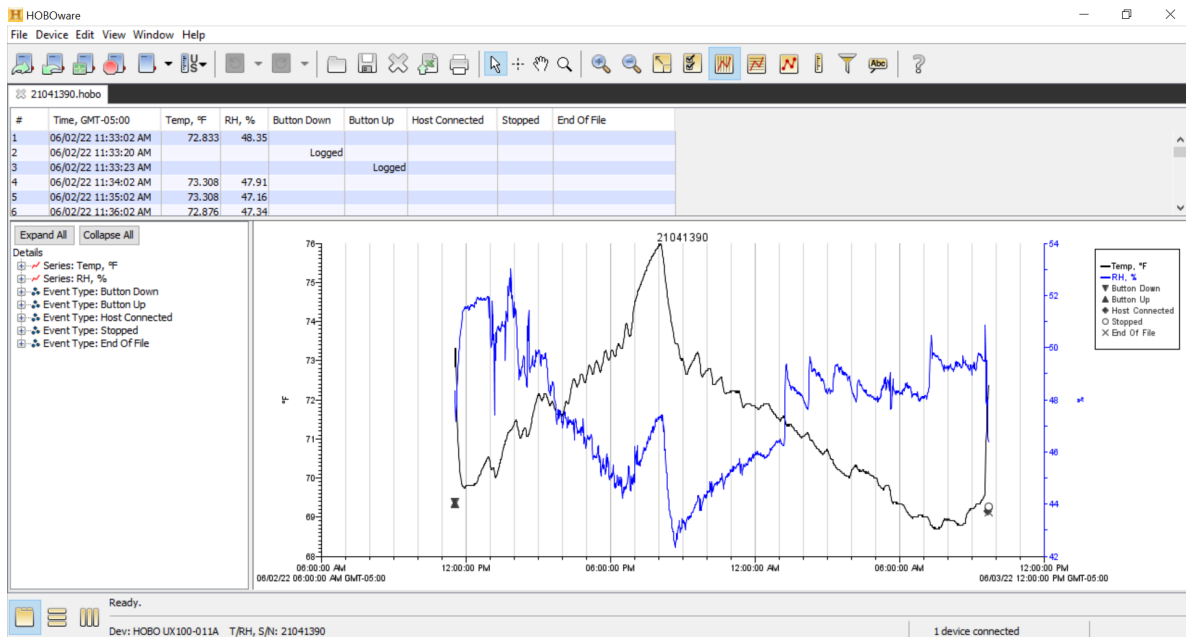
## Data Loggers [all audits]

### Data Loggers II: Analyze Data Lesson

Download Data into HOBOWare software:

*Approximate time: 1 hour*

1. Open HOBOWare software. Connect the logger to a computer with the USB cable. Click Device>Readout>Save File>Plot.

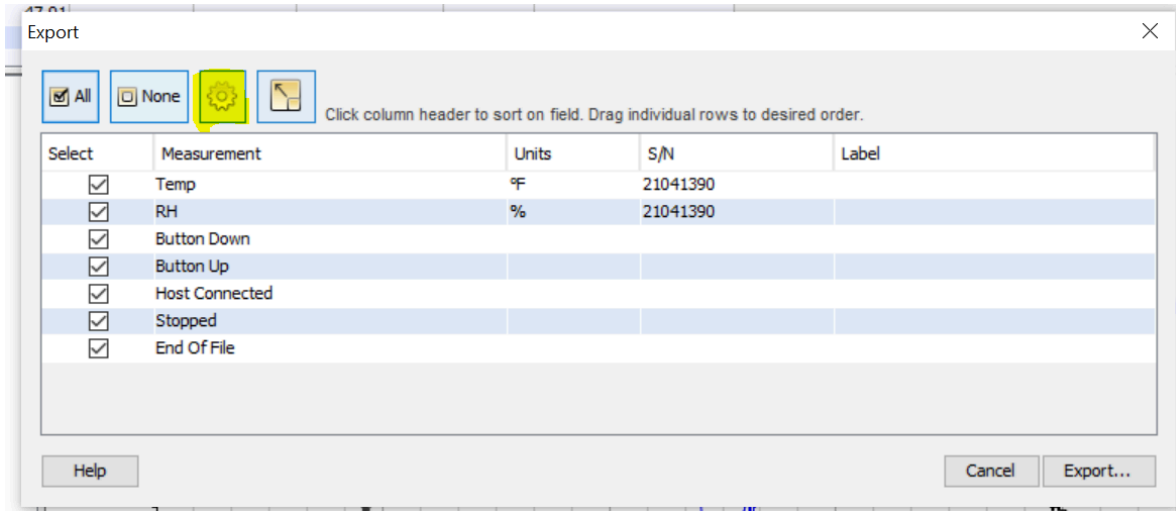


*Example image of data from a HOBO temp/RH logger.*

Export Data into Excel Spreadsheet:

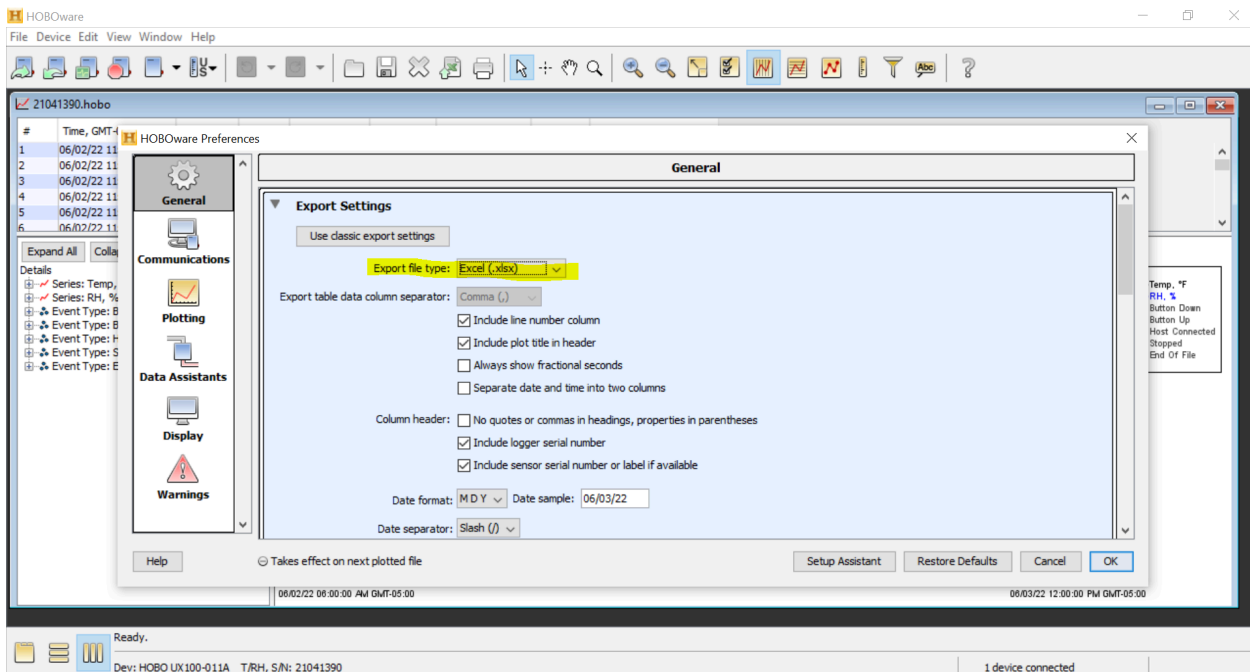
1. Click File>Export Table Data>Click on the wheel (highlighted in yellow).





Example image of data from a HOBO temp/RH logger.

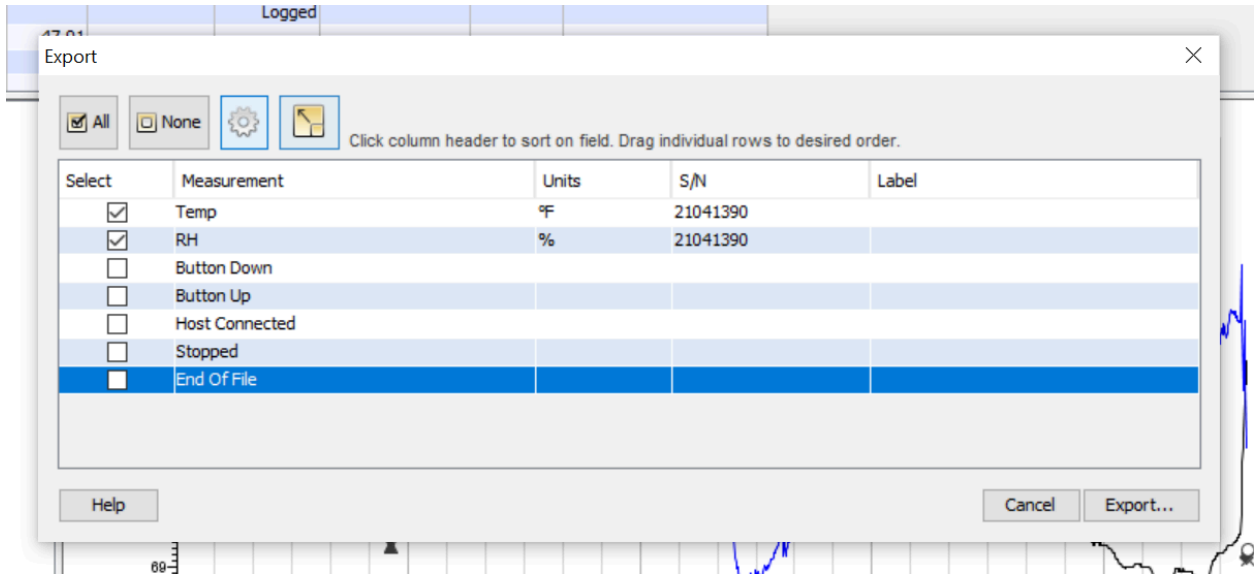
2. Check that it will export to Excel (highlighted in yellow) and not csv. Everything else is up to preference or you can leave it to default.



Example image of data from a HOBO temp/RH logger.



- Click OK. Deselect any measurements you don't need to see in the data. For example, see below:



Example image of data from a HOBO temp/RH logger.

- Click Export and Save it to your preference. Here is an example of what it might look like in Excel:

	A	B	C	D	E
1	Plot Title: 21041390				
2	#	Date Time, GMT-05:00	Temp, °F (	RH, % (LGR	S/N: 2104
3	1	02/06/22 11:33:02	72.833	48.3467	
4	2	02/06/22 11:34:02	73.308	47.9118	
5	3	02/06/22 11:35:02	73.308	47.158	
6	4	02/06/22 11:36:02	72.876	47.3396	
7	5	02/06/22 11:37:02	72.358	47.7897	
8	6	02/06/22 11:38:02	71.884	48.0323	
9	7	02/06/22 11:39:02	71.541	48.5039	
10	8	02/06/22 11:40:02	71.197	48.8518	
11	9	02/06/22 11:41:02	70.938	49.2592	
12	10	02/06/22 11:42:02	70.723	49.514	
13	11	02/06/22 11:43:02	70.551	49.8177	
14	12	02/06/22 11:44:02	70.38	50.0221	
15	13	02/06/22 11:45:02	70.293	50.2525	
16	14	02/06/22 11:46:02	70.165	50.3609	
17	15	02/06/22 11:47:02	70.079	50.5272	
18	16	02/06/22 11:48:02	70.036	50.66	
19	17	02/06/22 11:49:02	69.906	50.8324	
20	18	02/06/22 11:50:02	69.865	50.9026	
21	19	02/06/22 11:51:02	69.822	51.1345	

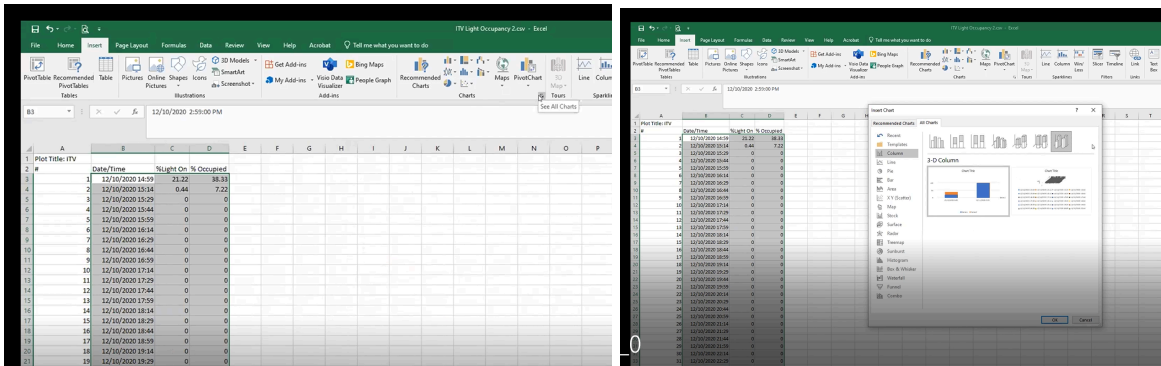
Example image of data from a HOBO temp/RH logger.



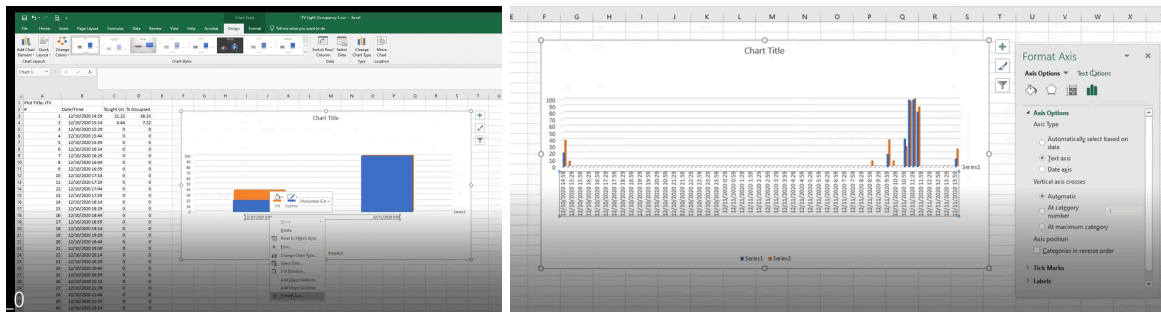
## Analyze Data in Excel Spreadsheet:

Create Charts (Example using light/occupancy data logger):

Once exported, we will create graphs in an Excel Spreadsheet or Google Slides. Select all the data (date/time, % Lights On, and % Occupied). You can also convert the data to seconds or minutes if you'd prefer. A quick way to highlight all data is to click on the first cell in the range you want to select. Scroll to the last cell in the range you want to select. Hold down your Shift key and click that cell. Click on "Insert" and then choose to add a chart. In Excel, you might need to click on "Recommended Charts" and then "All Charts." In Excel, you will choose a "3-D Column Chart" and in Google Slides, choose a "Column Chart" (or whatever chart type you prefer).



- In Excel, right click on the x-axis and click on "Format Axis..." Then click "Text Axis."



The images above are screenshots from Excel Spreadsheet creating a 3D chart from data.

- If there is a section where nothing is happening and you would like to exclude some data in your chart, in Excel you will right-click on the chart, choose "Select Data" and change which data is being included in the chart. Using Google Slides, you will right-click on the chart, choose "Data Range" and then choose which data you want to include.
- One idea for analyzing data if you prefer to work in seconds, minutes, or hours, rather than percent of time: Add a column after each of the "% Lights On" and "% Occupied" columns. For seconds, these columns will be "seconds lights on" and "seconds occupied." To convert the % time to seconds, you can follow the example below using a 15-minute interval:



- = % lights on during interval value x 15 minutes/interval x 60 seconds/minute ÷ 100 (to convert from percent).

Other notes:

- A line graph might be best for analyzing the plug load logger data.
- How do you delete files on the data logger? When you relaunch a HOBO data logger, the device reverts to the beginning of its memory and starts writing new data over the old.



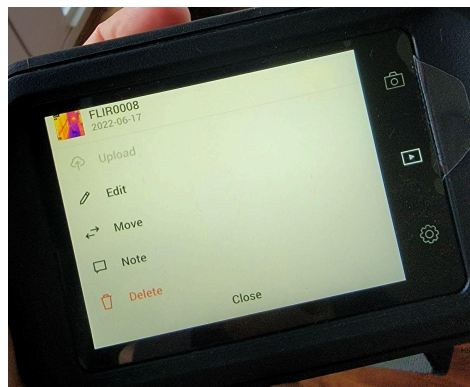
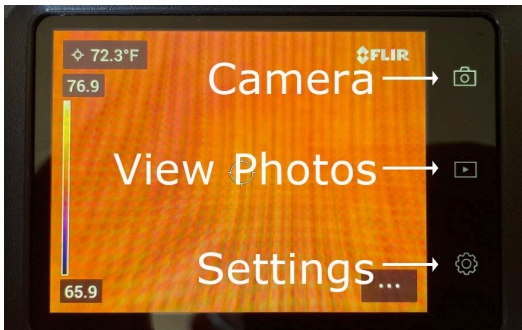
# Infrared Camera FLIR C3-X & Battery [Building Envelope Audit]



To take images:

1. Turn on the power button located on the top.
2. Aim the camera toward the area, wait for it to calibrate, and then observe the temperature in the left-hand corner. You will also see a temperature scale on the side of the camera. This will show you the range of temperatures the camera is observing. If interested, snap a picture by clicking on the long button on top.

3. There are three buttons along the right-hand side of the camera (see top-left image below. The top button is the camera view, the second button is for reviewing saved photos, and the third is for settings. Depending on your camera, the menu items might be slightly different, but you should be able to view both the infrared image and the digital camera image. Once you tap on a photo, there should be a button that looks like three dots in the top right. You can tap on that to view more details, take notes (such as “Classroom #2 ceiling”), or delete photos. Some examples of what this looks like are shown in the photos below. Be sure to download photos to a safe place before deleting them from the camera.



To download images to a computer:

1. Use the USB connector and plug it into your computer and the camera.
2. Press the power button and the computer should recognize the device and ask how you want to save the photos. Place these photos in a safe place (google drive folder) so that you can use them for your short report as well as future presentations. Don't forget to name them (Examples: Insulation problem in classroom #4 ceiling, air leak near HVAC, etc.) Once the photos have been moved to a safe place you can delete them from the camera.

To charge the device:




- You can use the USB connector and plug it into your computer.
- You can use the FLIR battery pack located in the infrared camera bag to charge it.
- If you have a USB outlet, you can charge it there, too.

Note:

Infrared cameras are best used in situations of extreme temperatures. If it is cold, you will be able to see where your building is losing heat. They can also pick up water damage, especially in materials that would start to disintegrate or compact with the addition of water. They can also be used to locate electrical hot spots.



# Measuring Devices [Building Envelope Audit]

<p><b>Measuring Wheel</b></p> 	<p>Measuring Wheel: This is best for areas too large to use a different device. Examples include outdoor areas, areas with a lot of foot traffic, curved perimeters, etc.</p> <p>How to Use Measuring Wheel (from the Johnson Level website):</p> <ol style="list-style-type: none"><li>1. Make sure the wheel surface is clean. Any dirt or loose impediments can affect the measurement. Remember, the length is based on the wheel's rotation.</li><li>2. Place the tool exactly where the measurement starts. Rotation is proportional to length, so it's important to keep starting and ending points precise.</li><li>3. As you walk, keep a steady pace. Changing pace can affect the wheel's rotation.</li><li>4. When you reach your ending point, pick the device up. This avoids any further wheel rotation.</li><li>5. Take your measurement and record data on your <a href="#">11 Building Envelope Audit Handout</a>.</li></ol> <p>Source: <a href="https://www.johnsonlevel.com/News/SurveyorsWheel">https://www.johnsonlevel.com/News/SurveyorsWheel</a></p>
<p><b>Measuring Tape</b></p> 	<p>Measuring Tape: Measure doors, windows, smaller areas, and equipment. Record data on the <a href="#">Building Envelope Audit Handout</a>.</p> <p>Video: How to measure a building: <a href="https://youtu.be/1ZownXypwUU">https://youtu.be/1ZownXypwUU</a></p>
<p><b>Laser Distance Measurer (or Range Finder)</b></p> 	<p>Laser Distance Measurer (Range Finder): We typically use this device to measure longer internal distances (e.g., room square footage), although it can come in handy in smaller spaces. It can also be used outside, but the laser pointer can be difficult to see in the sun.</p> <p>How to measure length, area, and continuously like a tape measure: <a href="https://www.lowes.com/pdf/BoschLaserTool/DLR130K_MyLowes-FrontBack-r1.pdf">https://www.lowes.com/pdf/BoschLaserTool/DLR130K_MyLowes-FrontBack-r1.pdf</a></p> <p>Be cautious as to where you point this device. It can be particularly useful to measure straight lines, like the floor-to-ceiling height.</p>





# Omega 4 in 1 - Light Meter [Lighting Systems Audit]



1. Push the power button (blue) and make sure the numbers are in Ft-Cd (foot candles). If it says “Lux,” you will press the “Lux/Ft-cd button.” If it does not show “Ft-Cd” or “Lux,” you will need to press the “Function” button until the display says “Light.”
2. Place the light meter where you want light and stand by to not cause shadows over the light meter. Examples might be at a student’s desk, teacher’s desk, a lab table, etc. Remember, the white bulb on the device is what will measure the amount of light in the room.
3. Reference standard lighting levels in a school to see if there is too much or too little light in the space. <https://www.gsa.gov/node/82715>
4. Record data in the K-12 Energy Benchmarking Tool Spreadsheet.

Note: This should not be used outdoors or in direct line of sight of the sun.



# Omega 4 in 1 - Thermometer

## [Building Envelope Audit]



1. Push the power button (blue) and wait until the numbers stop moving. Push the Function button until you see °F and %RH.
2. Record these numbers in the HVAC tab in the K-12 Energy Benchmarking Project Tool Spreadsheet.
3. You will want to compare the temperatures and relative humidity to the thermostat reading and the standards for the time of year. See the *Recommended Ranges of Temperature and Relative Humidity* table below.

### Recommended Ranges of Temperature and Relative Humidity

Relative Humidity	Winter Temperature	Summer Temperature
30%	68.5°F - 75.5°F	74.0°F - 80.0°F
40%	68.0°F - 75.0°F	73.5°F - 80.0°F
50%	68.0°F - 74.5°F	73.0°F - 79.0°F
60%	67.5°F - 74.0°F	73.0°F - 78.5°F

Recommendations apply for persons clothed in typical summer and winter clothing, at light, mainly sedentary, activity. Source: Adopted from ASHRAE Standard 55-1992, Thermal Environmental Conditions for Human Occupancy

Table from [EPA Reference Guide for Indoor Air Quality in Schools](#).



# HVAC Serial Number Lookup Example:



Image of faceplate information of a unit at Lyndon High School

Use this website for serial number lookups: <https://www.building-center.org>. Some serial number formats or equipment manufacturers may not be found on this website. If this happens, try a web search with the manufacturer name along with the words “serial number lookup.” If you’re unable to locate the serial number or determine its age, speak with your school’s facility manager. They might be able to provide you with the approximate age of the system. Steps to use the Building Center Website:

1. Select HVAC Index
2. Select the first letter of the HVAC brand name (L – for this example) then choose your brand (Lennox).
3. Review the serial number formats to find the format that matches. For this unit and serial number, it matched the first example. That will show you how to identify the year and month of manufacture. Using this example, the unit was manufactured in August 1993.
4. Use the ASHRAE Equipment Life Expectancy Chart (below) to gauge if the unit is beyond or approaching the median lifespan for that particular system.

Letter	Month	Letter	Month
A	January	G	July
B	February	H	August
C	March	J	September
D	April	K	October
E	May	L	November
F	June	M	December

Image from Building Intelligence Center website, Lennox example



## ASHRAE Equipment Life Expectancy chart

ASHRAE is the industry organization that sets the standards and guidelines for most all HVAC-R equipment.  
For additional info about ASHRAE the website is [www.ashrae.org](http://www.ashrae.org) .

Equipment Item	Median Years	Equipment Item	Median Years	Equipment Item	Median Years
<b>Air conditioners</b>		<b>Air terminals</b>		<b>Air-cooled condensers</b>	20
Window unit	10	Diffusers, grilles, and registers	27	Evaporative condensers	20
Residential single or Split Package	15	Induction and fan coil units	20	Insulation	
Commercial through-the wall	15	VAV and double-duct boxes	20	Molded Blanket	20 24
Water-cooled package	15	<b>Air washers</b>	17	<b>Pumps</b>	
<b>Heat Pumps</b>		Ductwork	30	Base-mounted	20
Residential air-to-air	15	Dampers	20	Pipe-mounted	10
Commercial air-to-air	15	<b>Fans</b>		Sump and well	10
Commercial water-to-air	19	Centrifugal	25	Condensate 15	
<b>Roof-top air conditioners</b>		Axial	20	<b>Reciprocating engines</b>	20
Single-zone	15	Propeller	15	Steam turbines	30
Multi-zone	15	Ventilating roof-mounted	20	Electric motors	18
<b>Boilers, hot water (steam)</b>		<b>Coils</b>		Motor starters	17
Steel water-tube	24 (30)	DX, water, or steam	20	Electric transformers	30
Steel fire-tube	25 (25)	Electric	15	<b>Controls</b>	
Cast iron	35 (30)	<b>Heat Exchangers</b>		Pneumatic	20
Electric	15	Shell-and-tube	24	Electric	16
<b>Burners</b>	21	<b>Reciprocating compressors</b>	20	Electronic	15
<b>Furnaces</b>		<b>Packaged chillers</b>		<b>Valve actuators</b>	
Gas- or oil-fired	18	Reciprocating	20	Hydraulic	15
<b>Unit heaters</b>		Centrifugal	23	Pneumatic	20
Gas or electric	13	Absorption	23	Self-contained	10
Hot water or steam	20	<b>Cooling towers</b>			
<b>Radiant Heaters</b>		Galvanized metal	20		
Electric	10	Wood	20		
Hot water or steam	25	Ceramic	34		

Source: [https://www.naturalhandyman.com/iip/infhvac/ASHRAE\\_Chart\\_HVAC\\_Life\\_Expectancy.pdf](https://www.naturalhandyman.com/iip/infhvac/ASHRAE_Chart_HVAC_Life_Expectancy.pdf)



## Identifying Efficiency Ratings:

Once we have the serial number and age of the system, it's important to identify the efficiency rating of the system, if possible. For air conditioners, this will most commonly be expressed as the Seasonal Energy Efficiency Ratio (SEER), a two-digit number. For furnaces, it is typically the Annualized Fuel Utilization Efficiency (AFUE), a percentage. The higher the number, the more efficient the system is. Follow the steps and use the links to look up information.

Places to look for the efficiency rating:

1. On the system itself
  - a. Look at the faceplate information and other tags on the system that may show the efficiency rating or the input and output in Btu/h.
  - b. With heating systems, you can divide the output Btu/h by the input Btu/h and multiply by 100 to get a percentage of the system's efficiency.
2. Internet search
  - a. Search the brand name and model number for information from the manufacturer.
  - b. It may be difficult to find useful information on old systems.
  - c. Sometimes the serial number will also include information about the equipment size, efficiency options, etc., but you will need to do a web search for this manufacturer-specific information.
3. Make an assumption
  - a. If the methods above did not work, you might need to make an assumption of the efficiency rating based on the minimum efficiency standards in the year the system was manufactured.
  - b. Use the links below to find the minimum standards in a year for different systems.

### Helpful resources:

Air conditioners

<https://www.eesi.org/papers/view/fact-sheet-air-conditioner-efficiency-standards-seer-13-vs.-seer-12>

Furnaces

<https://www.eia.gov/todayinenergy/detail.php?id=20011>

All systems

<https://www.energy.gov/eere/femp/incorporate-minimum-efficiency-requirements-heating-and-cooling-products-federal>.



# Baldr Wattmeters/Energy Meter

## [Electrical Appliances Audit]

1. Plug the watt meter into an outlet. If you hit the “set” button you change the setting to your preference.
2. You can choose to have students calculate the power:  $P=I \times V$  (P=power, I=Current aka amps, V=Voltage)
3. Here is an example of what the watt meter screen might look like with an appliance plugged in. You will record data in the K-12 Energy Benchmarking Tool Spreadsheet (Electrical Appliances Tab). Remember, a watt meter is just the instant energy usage at that specific moment.



Record the following data in the Benchmarking Tool spreadsheet:

Device is on and in use:

- Quantity of item
- Watts (W)
- Hours/day item is on

Device is asleep or on standby:

- Watts (W)
- Hours/day item is on standby

*This is an image of the BALDR Watt Meter actively collecting energy data from a laptop.*

