

Energy monitoring for cultural heritage institutions

IMAGE PERMANENCE INSTITUTE
TRAINING SUSTAINABLE ENVIRONMENTAL MANAGEMENT TEAMS FOR CULTURAL INSTITUTIONS
February 19, 2021



NATIONAL
ENDOWMENT
FOR THE
HUMANITIES

ipisustainability.org

Webinars

The following webinar is being offered with funding from the [National Endowment for the Humanities](#), Division of Preservation and Access, Education and Training Grant Program.

There is no cost to attend the webinar, register below to participate.

Upcoming Webinars

Energy Monitoring for Cultural Heritage Institutions

February 19, 2021 – 2:00pm - 3:00pm EST

This webinar will explain why institutions should consider energy monitoring, different strategies for doing so, and how the data collected can inform decision-making. IPI's Christopher Cameron and Kelly Krish will discuss energy use in collecting institutions, and both passive and active ways to reduce it. Martin Schooping from the Golisano Institute for Sustainability at RIT will talk about different strategies for energy monitoring and how to evaluate the subsequent data. Samantha Owens and Stephen Carrick from Glenstone Museum will then present a case study of how they have successfully implemented and used energy monitoring at their institution to inform sustainability goals and make changes.

[Register Now](#)



Recent Webinars

Responding to Issues

July 9, 2020

[Watch the Recording](#) or [Download the Presentation \(PDF\)](#)

Setting Appropriate Parameters

June 11, 2020

[Watch the Recording](#) or [Download the Presentation \(PDF\)](#)

Understanding Fluctuations and Equilibrations

May 14, 2020

[Watch the Recording](#) or [Download the Presentation \(PDF\)](#)

Evaluating Collection Spaces

August 16, 2019 (Beginner)

Presenters



Kelly M. Krish

Preventive Conservation
Specialist

**Image Permanence
Institute, RIT**



Christopher Cameron

Sustainable Preservation
Specialist

**Image Permanence
Institute, RIT**



Martin Schooping

Senior Program
Manager

**Golisano Institute of
Sustainability, RIT**



Samantha Owens

Assistant Conservator

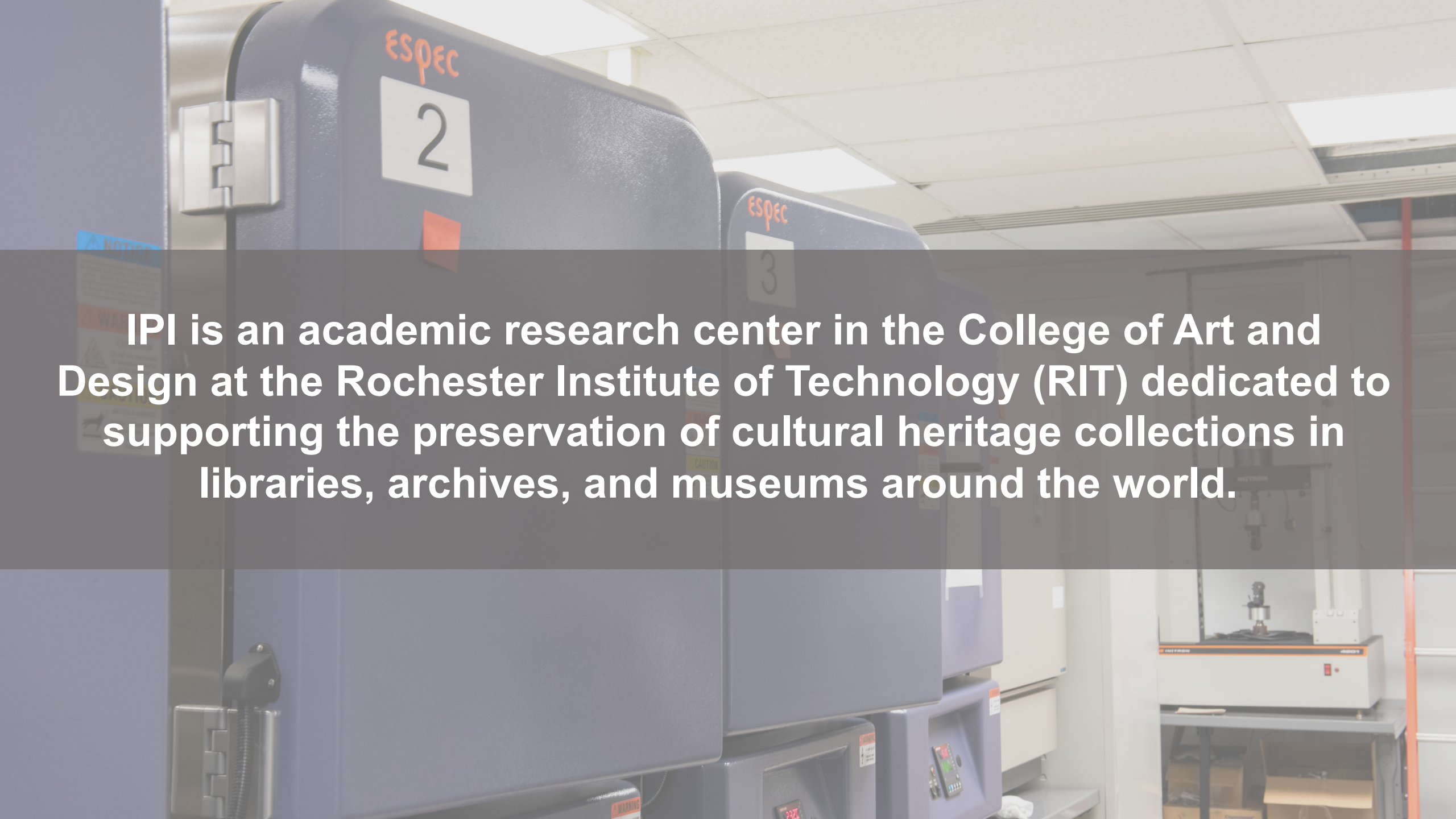
Glenstone Museum



Stephen Carrick

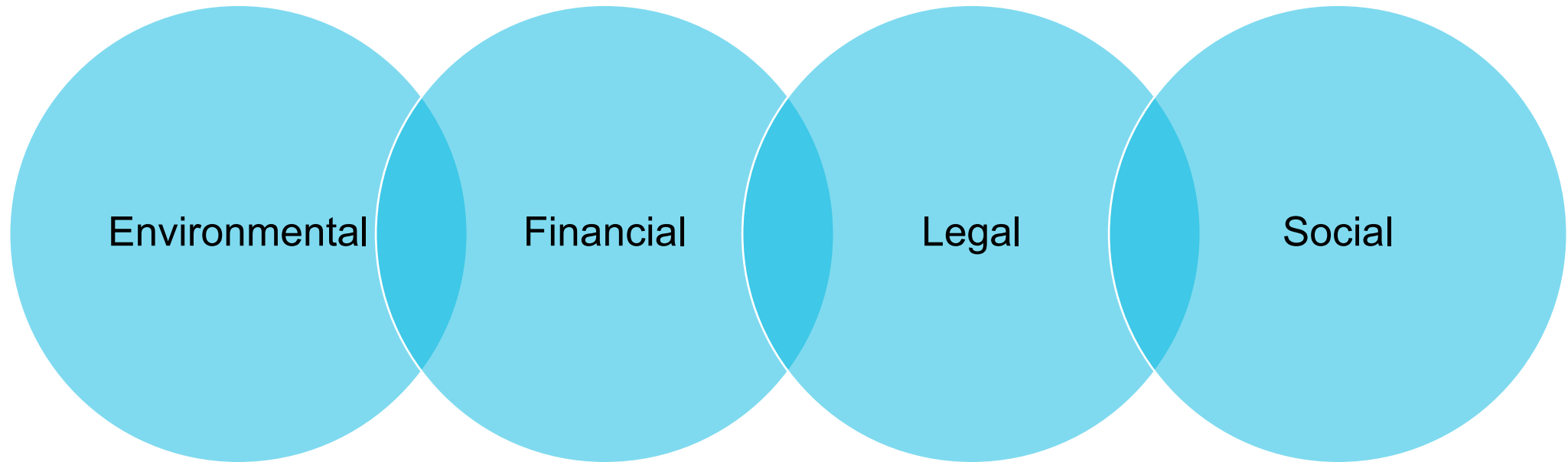
Director of Engineering
and Maintenance

Glenstone Museum



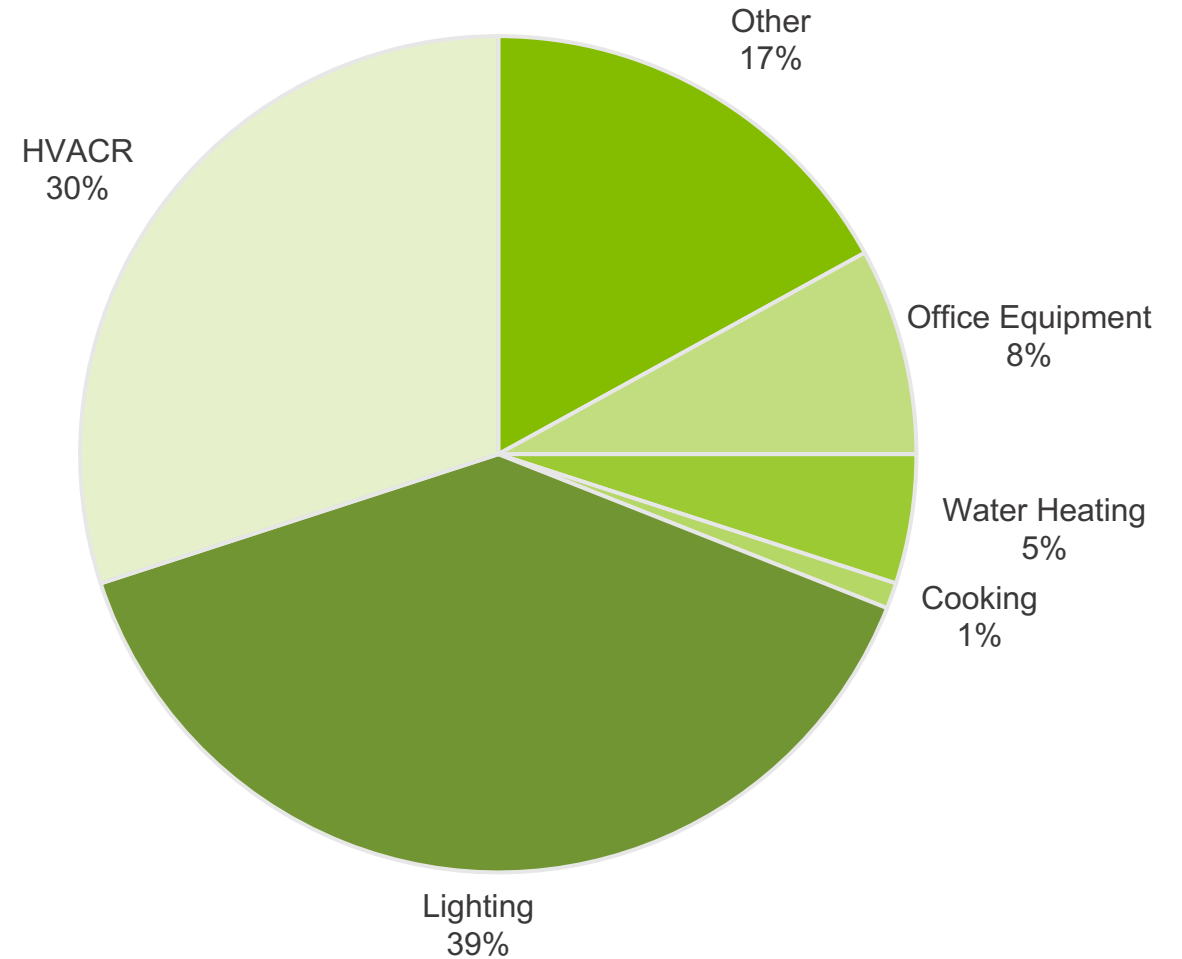
IPI is an academic research center in the College of Art and Design at the Rochester Institute of Technology (RIT) dedicated to supporting the preservation of cultural heritage collections in libraries, archives, and museums around the world.

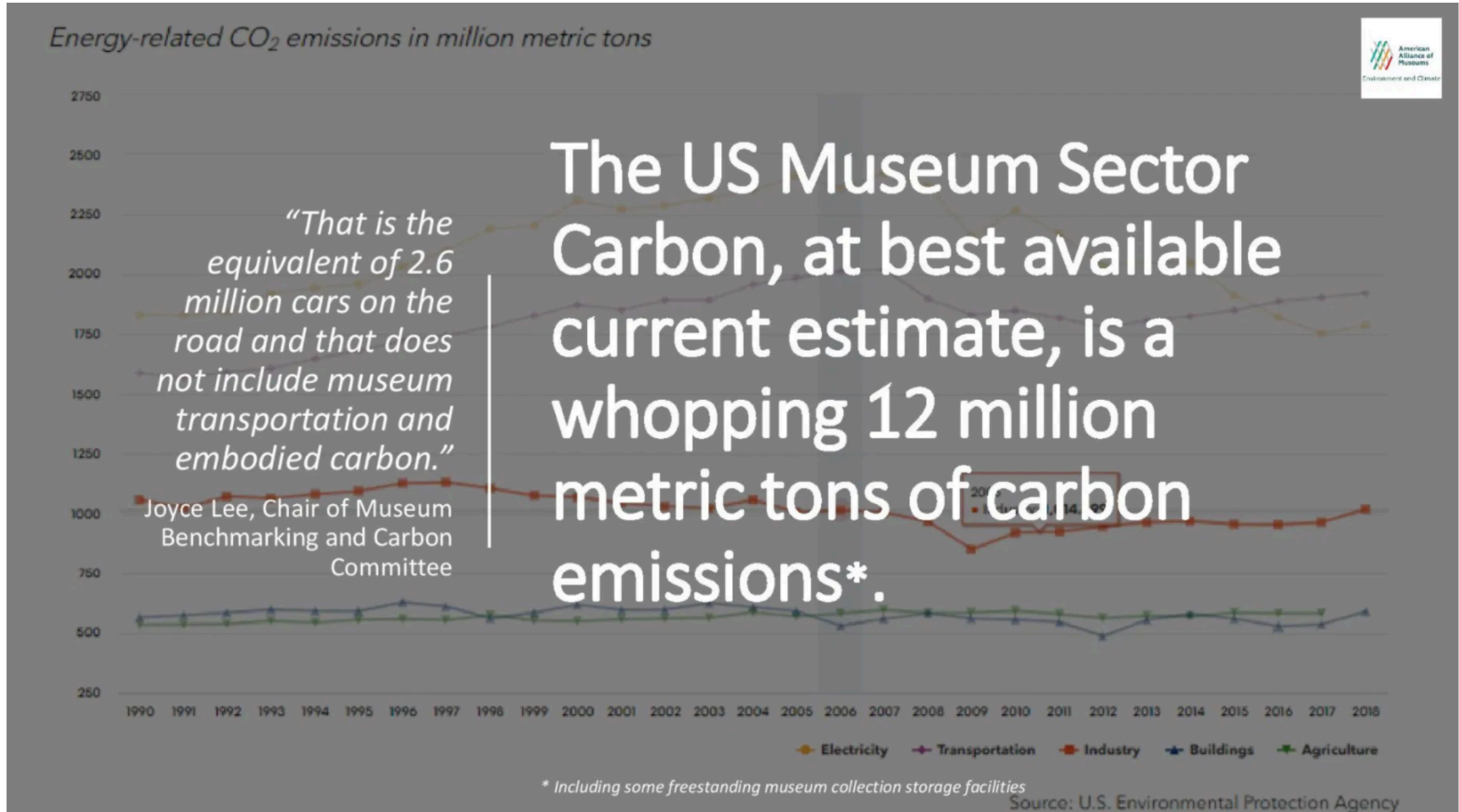
Why should we consider energy monitoring?



Opportunities for reducing energy usage

Average energy consumption in
commercial buildings





Reduce energy usage through passive means

Levels of Control

- ▶ Policies/ procedures
- ▶ Location/ site
- ▶ Building
- ▶ Room
- ▶ Storage Unit
- ▶ Object



Methods of Control

- ▶ Avoid
- ▶ Block
- ▶ Reduce
- ▶ Detect
- ▶ Respond

Reduce thermal and moisture loads



Reduce air leakage

“Air leakage is reportedly considered to be the greatest source of heat loss in buildings and a big contributing factor in a building’s energy use for heating or cooling. As such, mandating these tests would go a long way towards reducing a building’s energy consumption.

Researchers noted that improved air sealing, increased insulation levels, and high-performance windows and doors are integral to buildings aiming for net-zero readiness.”

<https://www.reminetwork.com/articles/energy-efficiency-new-building-codes-report/>

Reduce air leakage

Identify potential air leaks in the facility

- ▶ Look for gaps in doors and windows
- ▶ Holes in the façade

On days with a significant difference between indoor and outdoor temperature, an IR camera can be used to identify locations for potential air leakage.



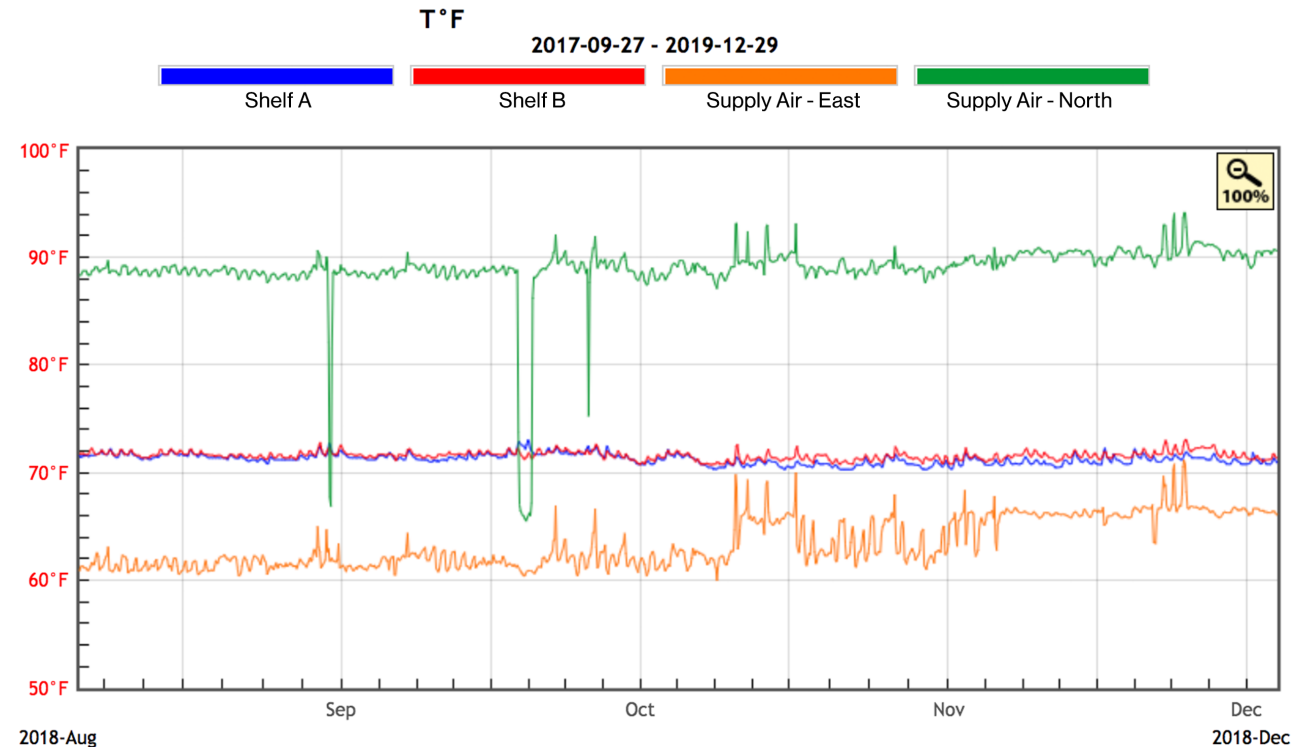
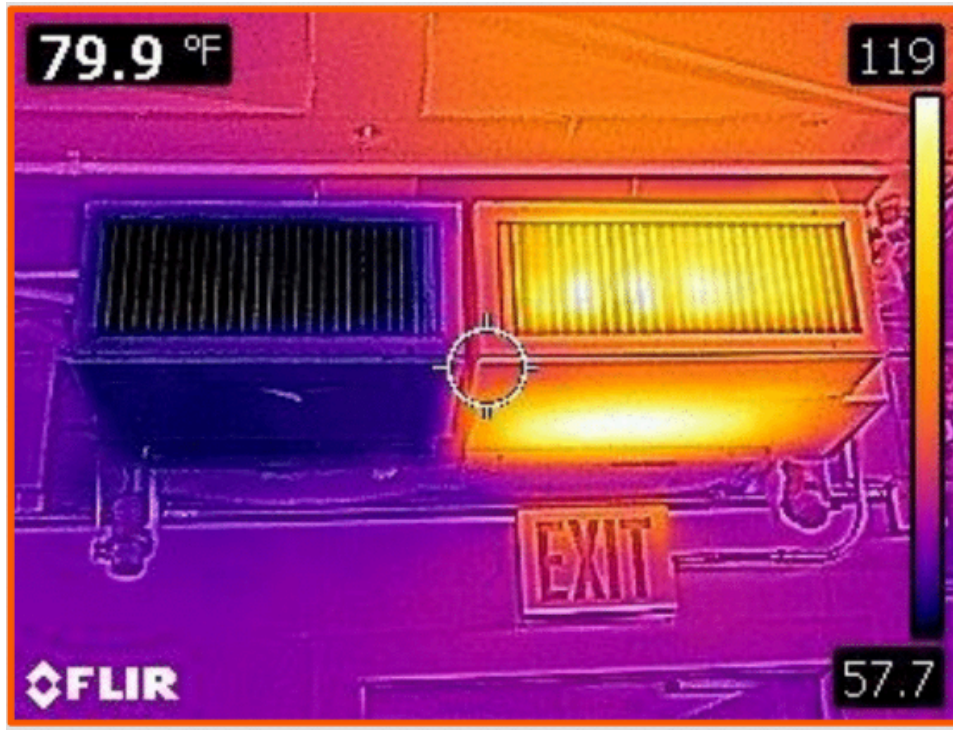
Keep up with preventive maintenance



Use microclimates to your advantage



Reduce mechanical energy usage



Example: heating and cooling

Guidebook

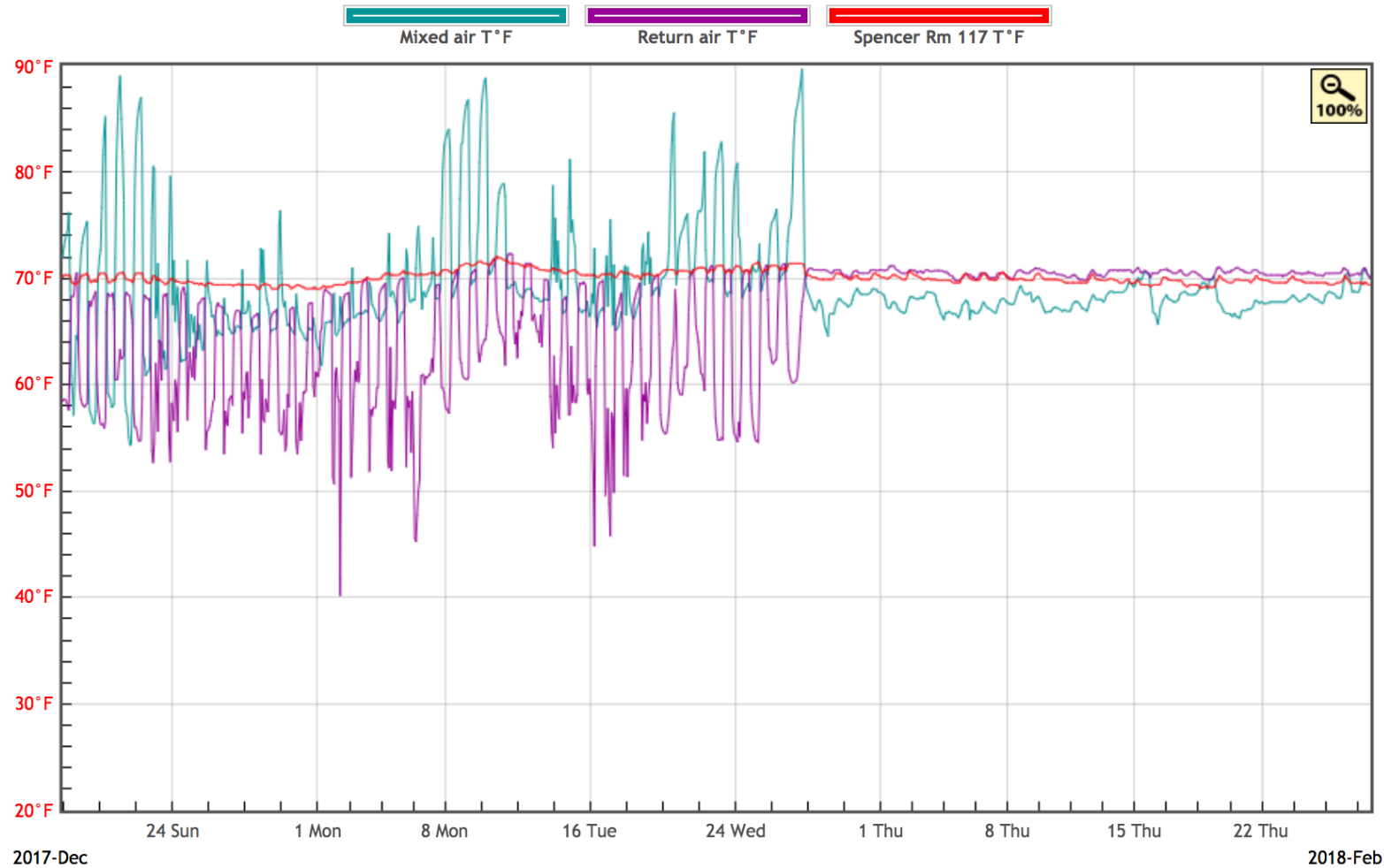
A how-to manual for mechanical system analysis

The guide walks you through a step-by-step process of how to perform a mechanical system analysis and how to implement various strategies to improve the collections environment.

<https://www.imagepermanenceinstitute.org/resources/publications/ipi-methodology-guidebook>



Example: system shutdowns



Energy monitoring for cultural heritage institutions

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February 19, 2021

Ki Book - Energy

<https://www.kiculture.org/ki-books/>

CALCULATE YOUR EMISSIONS



KI TOOL

The first step to offsetting is to decide how much carbon you are offsetting. To do this, you will need to calculate your emissions and then assign a price per tonne of CO₂. There are many different sources that you can use for calculating your emissions, but here are a few of our favorites:

Gallery Climate Coalition

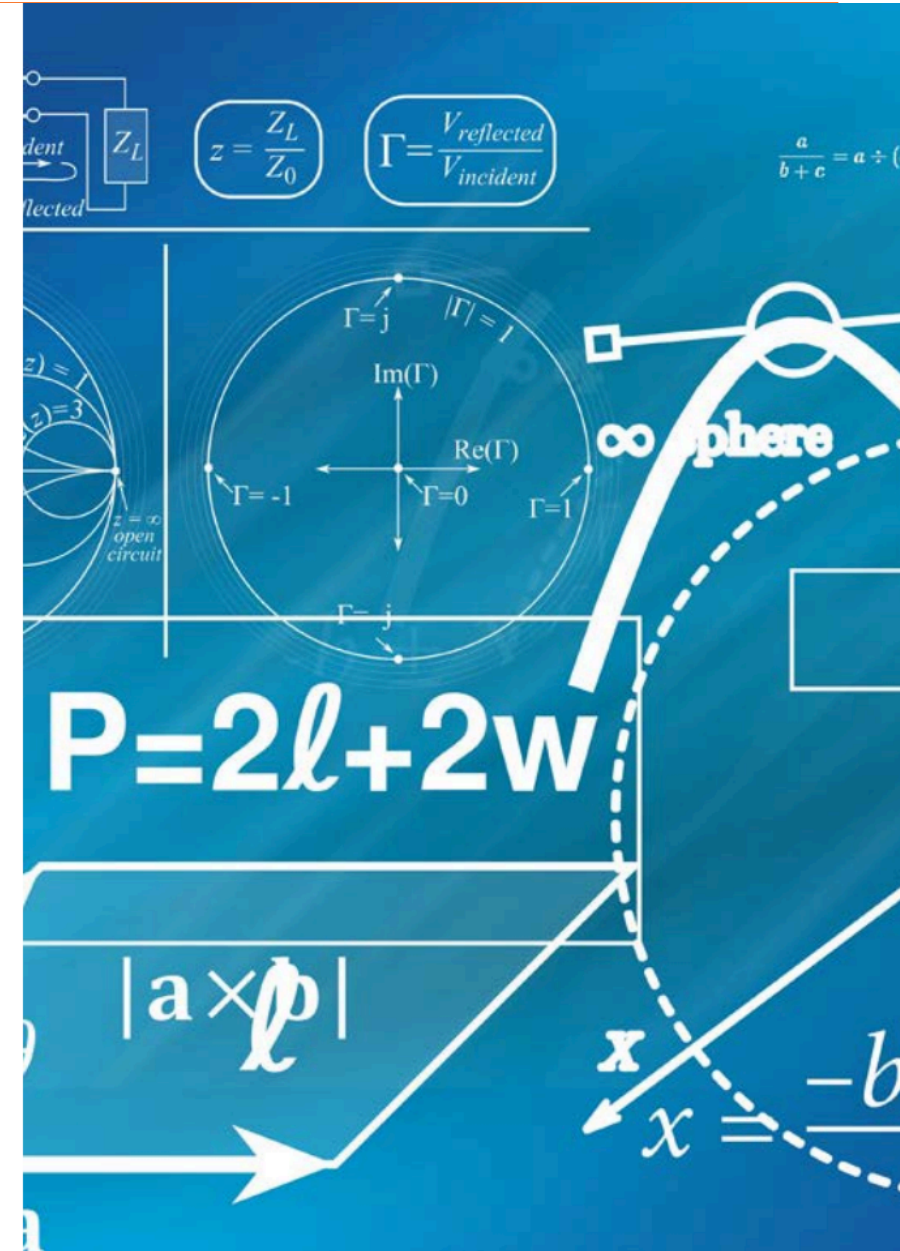
Carbon Fund

Climate Neutral Now

Carbon Footprint

Julie's Bicycle

Climate Partner



Thank you

Please complete
the brief post-
webinar survey to
provide us valuable
feedback!

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Energy Monitoring for Cultural Heritage Institutions

Energy Monitoring: Strategies and Evaluation

February 19, 2021



Martin Schooping

Sr. Project Manager

New York State Pollution Prevention Institute

Golisano Institute for Sustainability

Rochester Institute of Technology

W: 585-475-6759

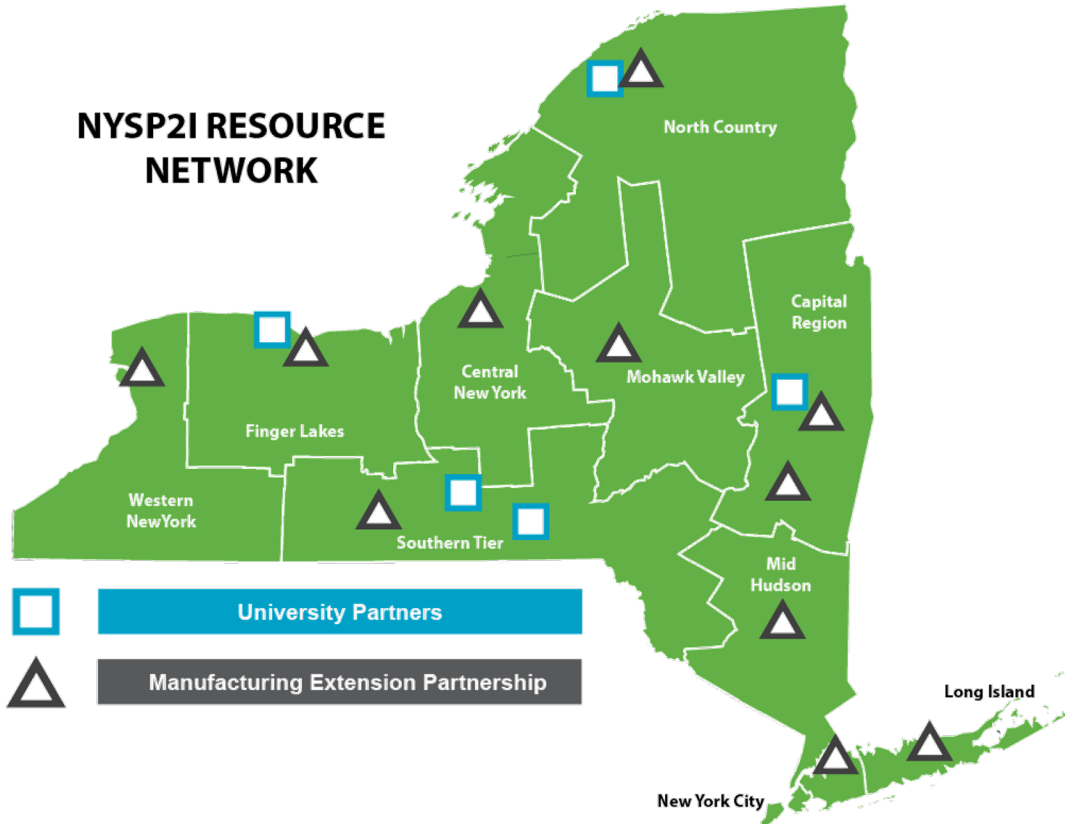
mpsasp@rit.edu



NYS Pollution Prevention Institute

- HQ at RIT
- Established in 2008
- \$3.9M in annual NYS funding administered through the NYS Department of Environmental Conservation
- Focus areas include:
 - Sustainable Manufacturing Assessments
 - Supply Chain Sustainability
 - Technology Commercialization
 - Food Waste Diversion
 - Outreach & Education
 - Research & Development
 - Emerging Contaminants

NYSP2I RESOURCE NETWORK



Department of
Environmental
Conservation



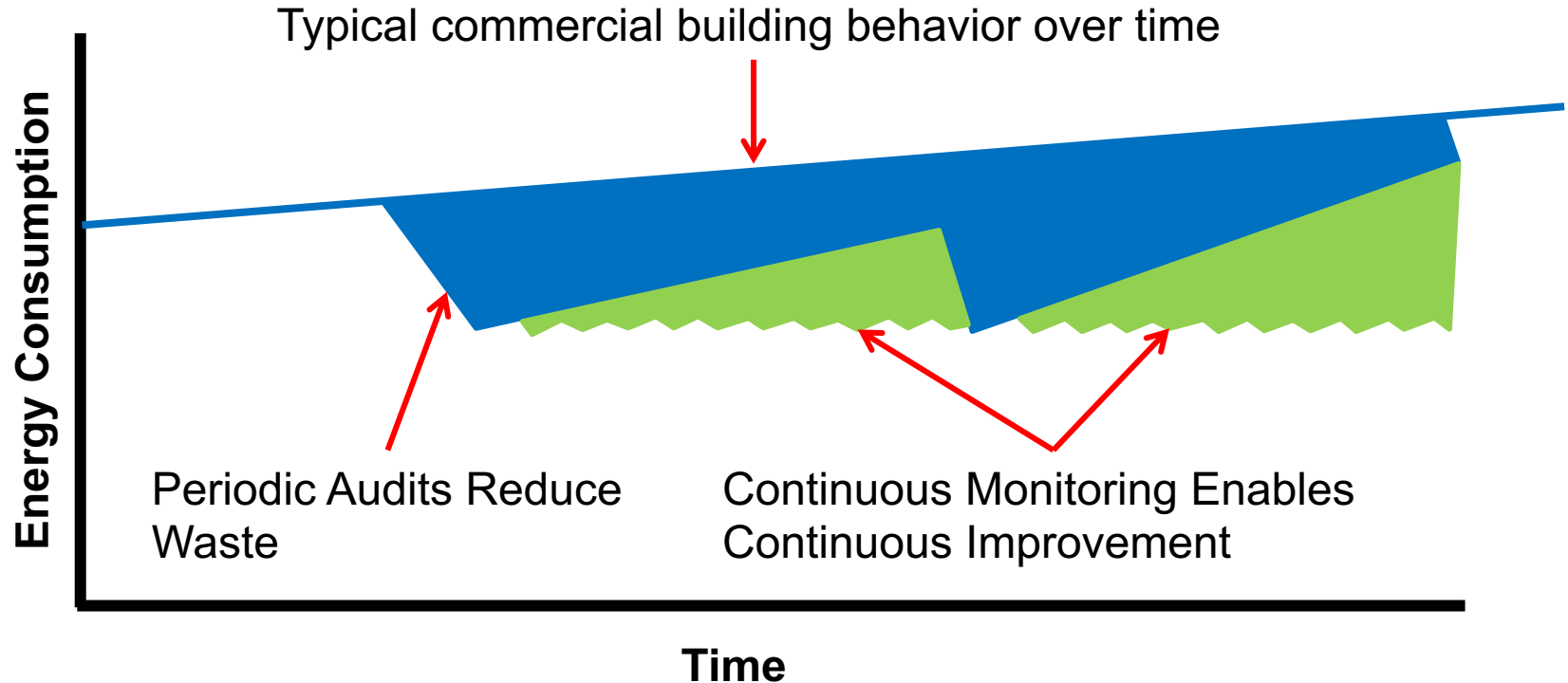
NEW YORK
Manufacturing
Extension Partnership

Assistance for NYS Companies, Municipalities & Non-Profits

- **Must be NY-based**
- **Typical project cost range is \$35-\$50k**
- **NYSP2I funding offsets most of the project cost to the organization**
 - Expenses are non-capital expenses
 - RIT's engineering, technical and project management services
- **Post-project reporting**
- **Typical project takes about 4-6 months**



Why monitor energy use?



Strategies for Energy Monitoring

■ Minimal

- Online tools
- Utility bill analysis
- Simple Predictive Model

■ Moderate


- Demand reduction
- Interval data analysis

■ Detailed

- Sub-metering

Minimal: Online Tools

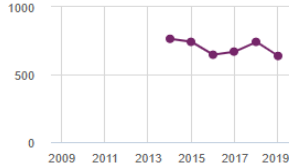
- Easy to enter data from utility bills or direct meter access
- Covers electric, gas, oil, water, waste
- Can view all portfolio properties in one view
- Allows the user to set sustainability goals
- Roll-up of GHG emissions
- Shows comparison metrics




ENERGY STAR®
PortfolioManager®

Welcome Account | Notifications | ENERGY STAR | Contacts | Help | Sign Out
YatesCounty: Settings Notifications

MyPortfolio Sharing Reporting Recognition

Properties (6)
Add a Property

Total GHG Emissions Trend (Metric Tons CO₂e)
[Change Metric](#)

(Chart current as of 08/11/2020 09:04 AM EDT) [Refresh Chart](#)


Manage Portfolio
 [Transfer ownership](#) of a property that you manage to another Portfolio Manager user.
 [Upload and/or update multiple properties](#) at once using an Excel spreadsheet if you are a pro. This can be done to create new properties, add

Dashboard (Metrics current as of 01/07/2021 09:59 AM EST) [Search by ID or Name](#)

View All Properties (6) Energy Highlights [Refresh Metrics](#)
[Add/Edit/Delete Groups](#) [Add/Edit/Delete Views](#)

Name	Energy Current Date	ENERGY STAR Score	Site EUI (kBtu/ft²)	Source EUI (kBtu/ft²)
Buildings and Grounds Office (B&G) 6786669	01/31/2020	NA	54.6	57.3
County Office Building (COB) 6786663	12/31/2019	76	66.6	119.6
Court House (CH) 6786667	12/31/2019	91	48.4	85.4
Highway Barn 6786670	11/30/2019	49	50.3	64.0
Highway Guyanoga Storage 6786673	11/30/2019	NA	0.6	1.7
Public Safety Building (PSB) 6786665	12/31/2019	NA	144.9	279.4

First Previous Page 1 of 1 Next Last 100 View 1 - 6 of 6
[Download Data Table](#)


ENERGY STAR®
PortfolioManager®

[Welcome](#) | [Account](#) | [Notifications](#) | [ENERGY STAR Notifications](#) | [Contacts](#) | [Help](#) | [Sign Out](#)
YatesCounty: [Settings](#)

Manage Bills (Meter Entries) for [County Office Building_\(COB\)](#)

Meter Selection: Electric Grid Meter



▸ **Basic Meter Information** (****click on the arrow to the left to expand this section*)

▾ **Monthly Entries**

Display Year(s): 2021

	Start Date	End Date	Usage kWh (thousand Watt-hours)	Total Cost (\$)	Estimation	Green Power	Demand (kW)	Demand Cost (\$)	Last Update
<input type="checkbox"/>	12/14/2020	1/14/2021	51,600	2,169.58	<input type="checkbox"/>	<input type="checkbox"/>			2/2/2021 YatesCount

✕ [Delete Selected Entries](#)
✕ [Delete All Entries](#)
✚ [Add Another Entry](#)
📖 [Learn how to copy/paste](#)

 [Download](#) to Green Button XML
 [Download](#) to Excel

Upload data in bulk for this meter:

📄 Use this [single-meter spreadsheet](#) to:

- Upload the completed file below
- Copy and Paste the data into the table above

EPA Portfolio Manager

- Converts all energy sources to common units
- Shows all energy sources on one chart

County Office Building (COB)


417 Liberty Street, Penn Yan, NY 14527 | [Map It](#)

Portfolio Manager Property ID: 6786663

Year Built: 2002

[Edit](#)

Not currently eligible for
ENERGY STAR
Certification

ENERGY STAR Score (1-100)
Current Score: 78

Baseline Score: 75

Summary

Details

Energy

Water

Waste & Materials

Goals

Design

Meter Summary

2 Energy Meters Total

2 - Used to Compute Metrics

[Add A Meter](#)

Current Energy Date

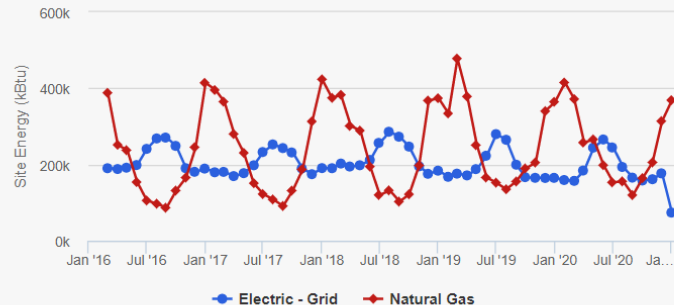
Dec 31, 2020

Enter Your Bills

Four Ways to Enter Bill Data

1. Manual ([Instructions here](#))
2. Use our simple spreadsheet (on the bottom of each meter's Manage Bills page) to upload or [Copy/Paste](#)
3. Use our [complex spreadsheet](#) (multiple meters + multiple properties)

Energy Use by Calendar Month (Not Weather Normalized)

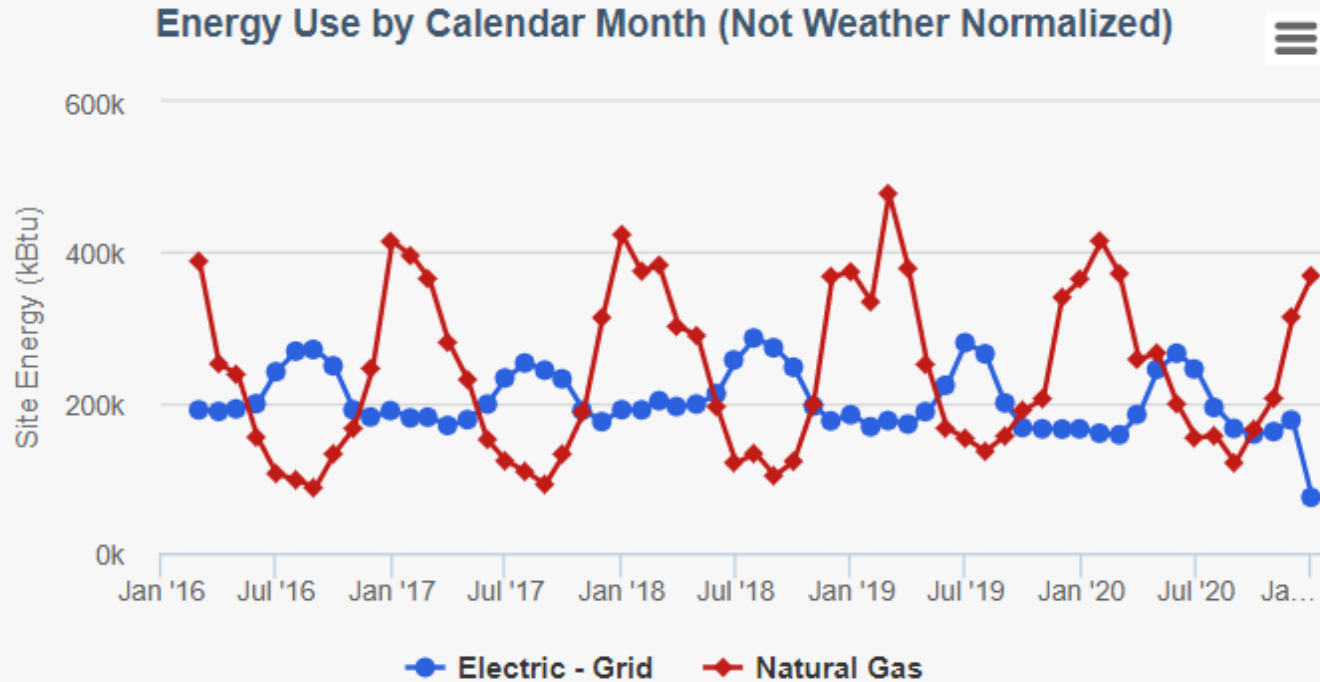

[Export Data by Calendar Month](#)

Meters - Used to Compute Metrics (2)

[Change Meter Selections](#)
[View as a Diagram](#)

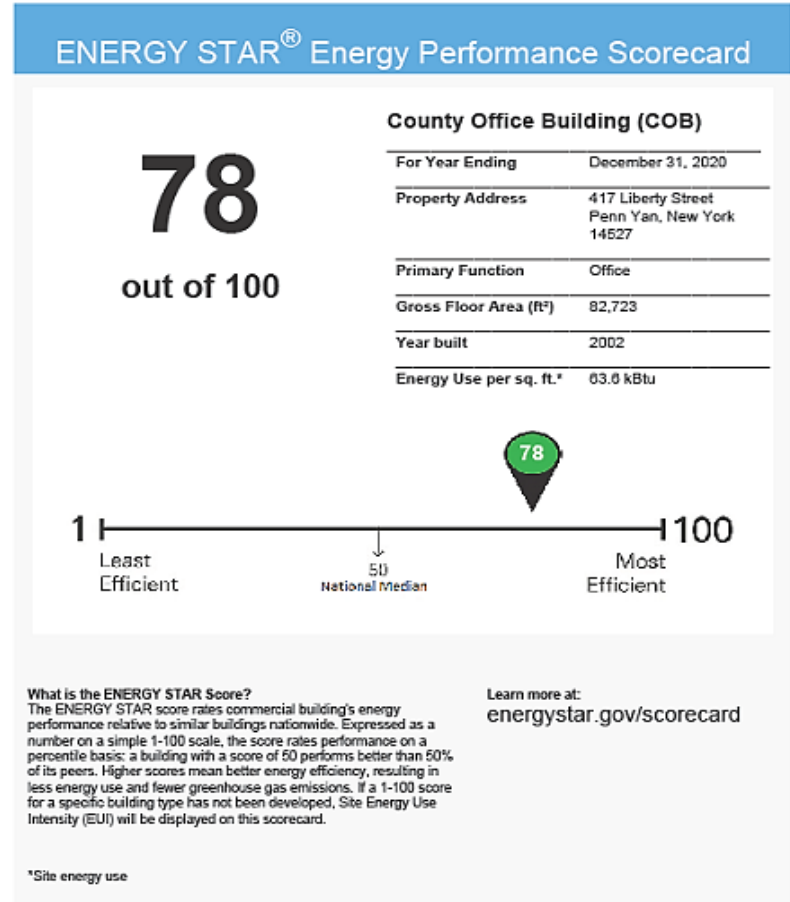
Add A Meter

EPA Portfolio Manager



EPA Portfolio Manager

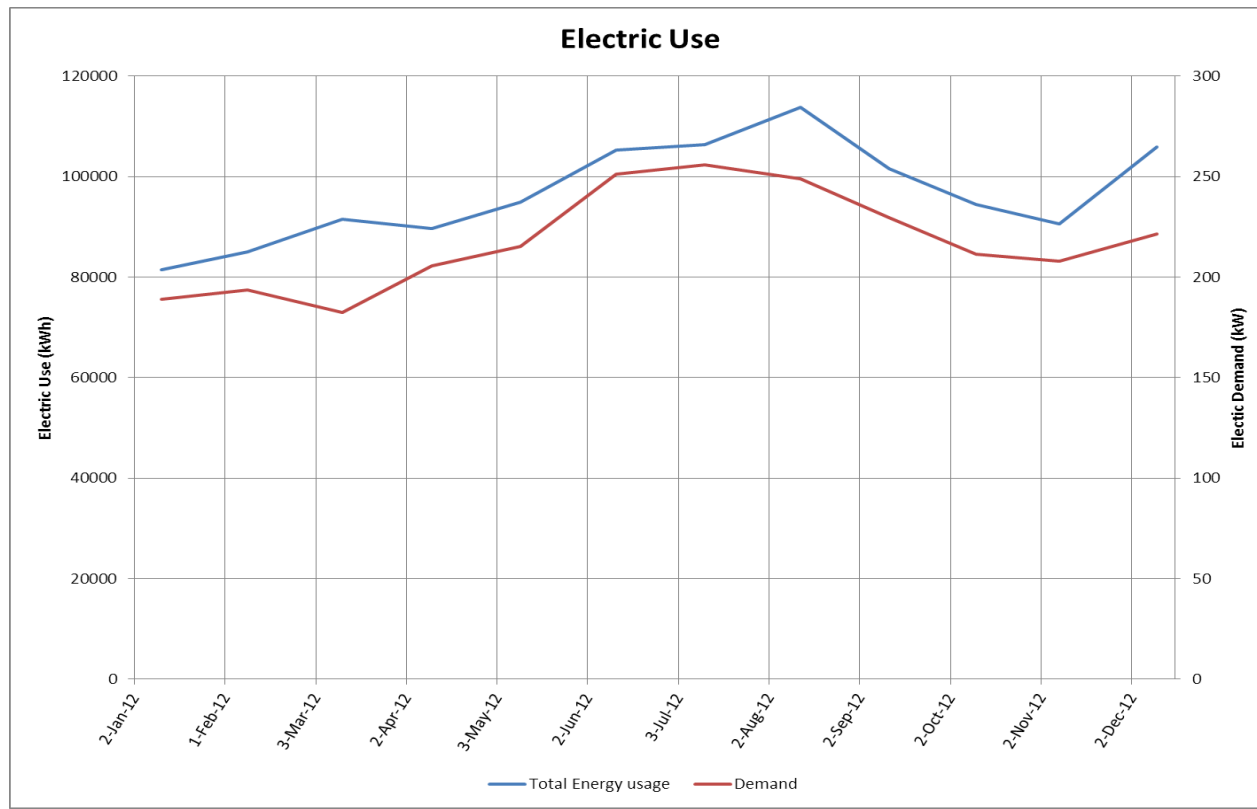
- Available Reports
 - Statement of Energy Performance
 - ENERGY STAR Scorecard
 - Progress and Goals Report
 - Data Verification Checklist
 - Water Scorecard



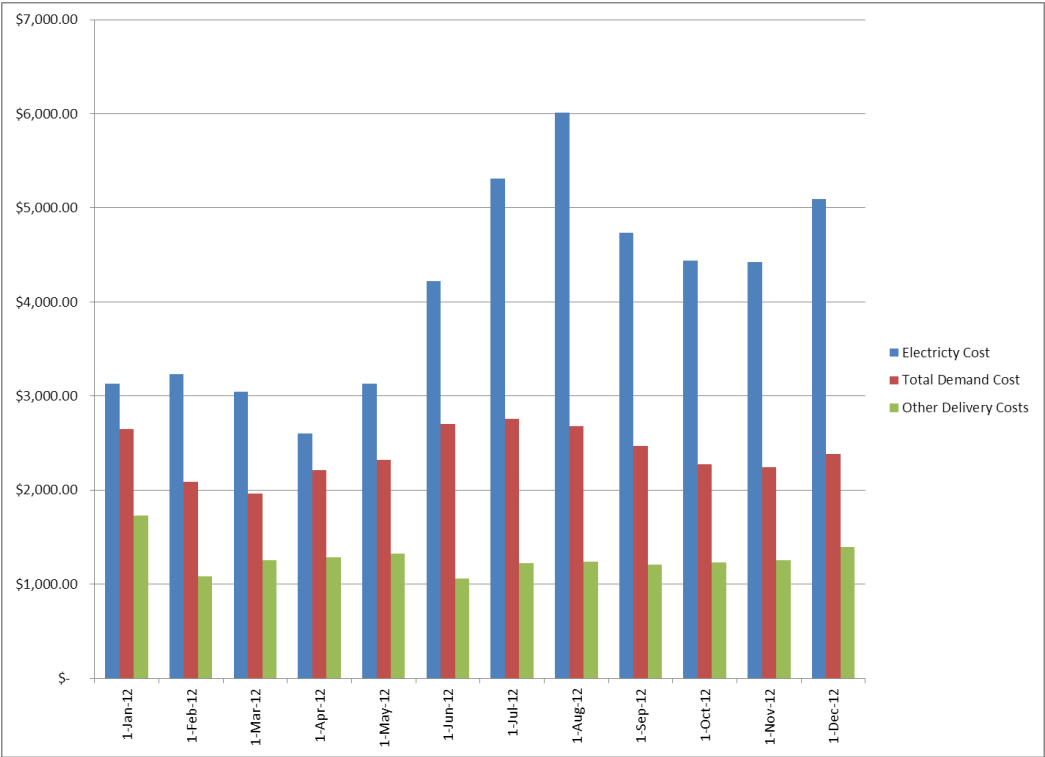
Minimal: Utility Bill Analysis

Data from Monthly Utility Bills

- Add Demand Charge data to better understand costs

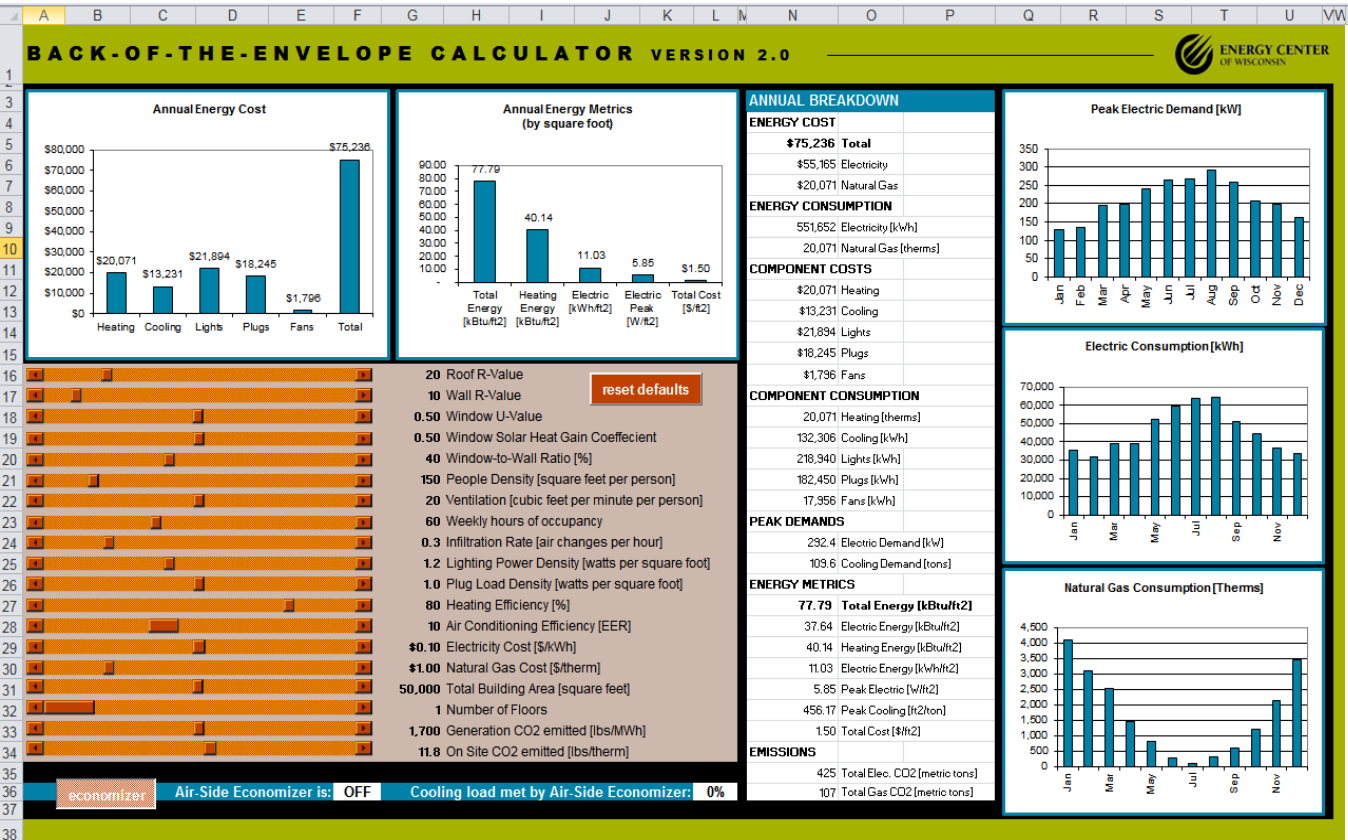


Data from Monthly Utility Bills



Minimal: Simple Predictive Model

Back of Envelope Calculator



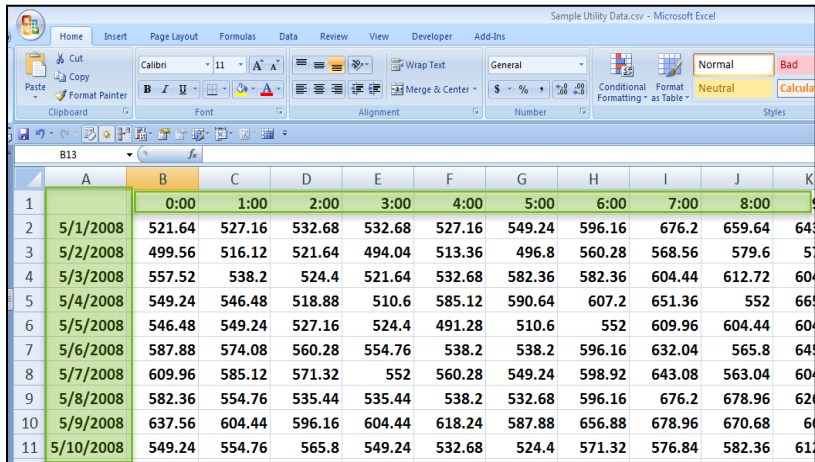
Courtesy of Energy Center of Wisconsin
<http://www.seventhwave.org/boecalculator>

Moderate: Meter Data Profile Analysis

Meter Data Analysis

- Meter profiles are like a heartbeat; it should show a variation as the building consumption goes up and down as the demand for services increases
- Periodic review of the meter profile will reveal inconsistent usage
 - However, this requires high resolution data, either hourly or 15-minute
 - Monthly billing data provides some useful information, but does not show time-of-use
- Utilities in many regions are installing interval meters that provide high resolution (typically 15-minute) interval data
- Data from the utilities can be downloaded from the utilities' website
 - Data is typically updated daily and up to 12 months of data is typically available online

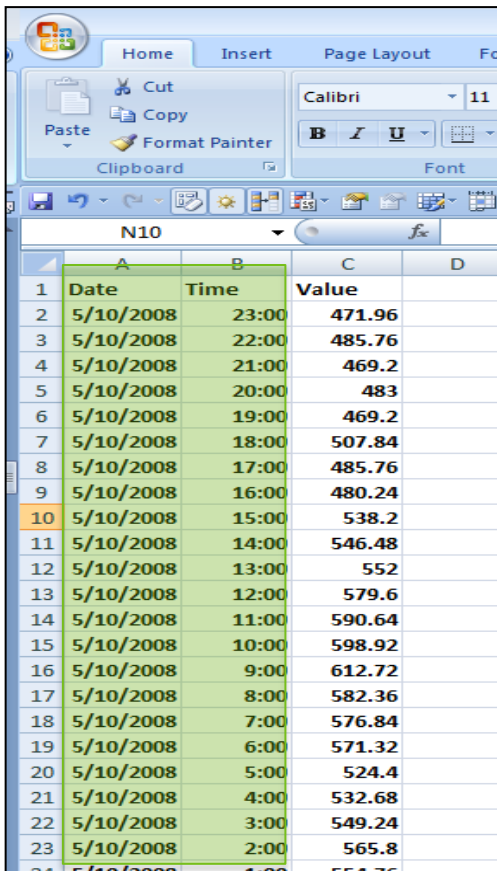
Meter Data: Format (ECAM)



	A	B	C	D	E	F	G	H	I	J	K
1		0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	
2	5/1/2008	521.64	527.16	532.68	532.68	527.16	549.24	596.16	676.2	659.64	643.2
3	5/2/2008	499.56	516.12	521.64	494.04	513.36	496.8	560.28	568.56	579.6	571.2
4	5/3/2008	557.52	538.2	524.4	521.64	532.68	582.36	582.36	604.44	612.72	604.44
5	5/4/2008	549.24	546.48	518.88	510.6	585.12	590.64	607.2	651.36	552	663.6
6	5/5/2008	546.48	549.24	527.16	524.4	491.28	510.6	552	609.96	604.44	604.44
7	5/6/2008	587.88	574.08	560.28	554.76	538.2	538.2	596.16	632.04	565.8	643.2
8	5/7/2008	609.96	585.12	571.32	552	560.28	549.24	598.92	643.08	563.04	604.44
9	5/8/2008	582.36	554.76	535.44	535.44	538.2	532.68	596.16	676.2	678.96	620.4
10	5/9/2008	637.56	604.44	596.16	604.44	618.24	587.88	656.88	678.96	670.68	643.2
11	5/10/2008	549.24	554.76	565.8	549.24	532.68	524.4	571.32	576.84	582.36	612.72

- Utilities typically provide data in the above format, which need to be converted into a format shown on the right – Energy Charting and Metrics Tool (ECAM) can convert that and also analyze the data for you

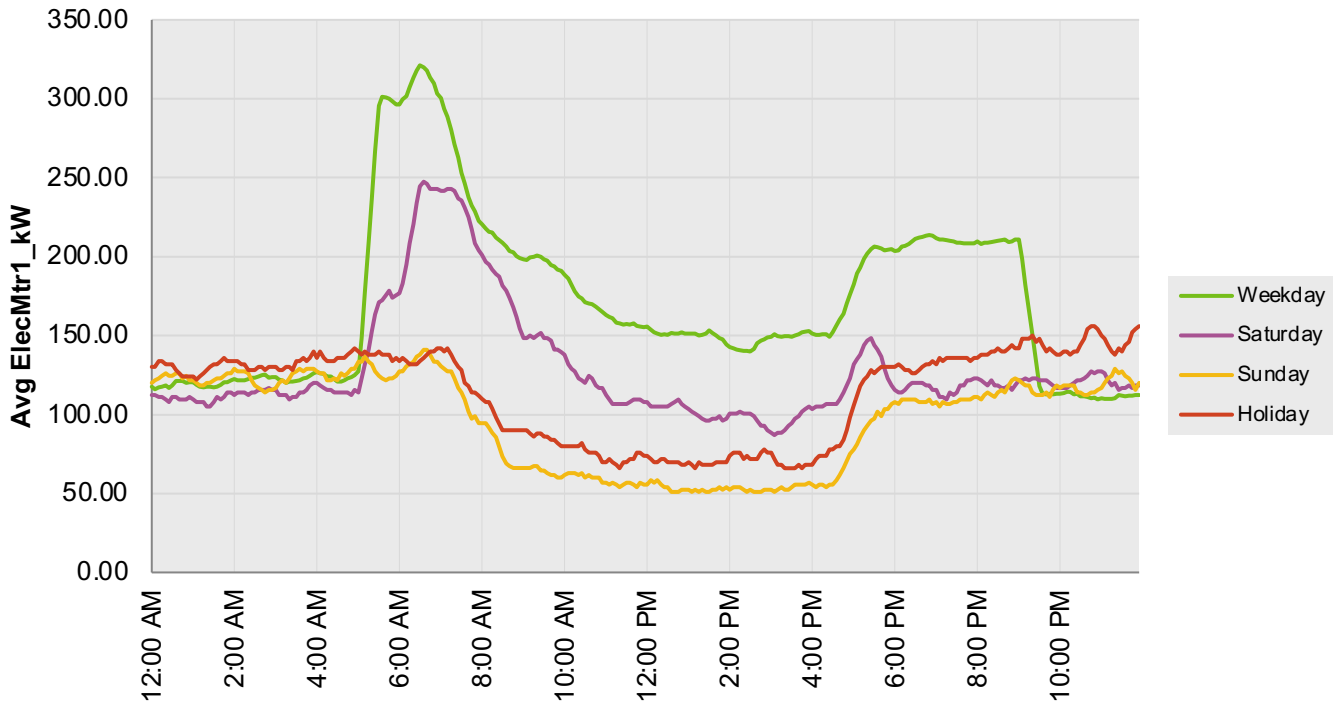
<https://buildingretuning.pnnl.gov/ecam.stm>



	A	B	C	D
1	Date	Time	Value	
2	5/10/2008	23:00	471.96	
3	5/10/2008	22:00	485.76	
4	5/10/2008	21:00	469.2	
5	5/10/2008	20:00	483	
6	5/10/2008	19:00	469.2	
7	5/10/2008	18:00	507.84	
8	5/10/2008	17:00	485.76	
9	5/10/2008	16:00	480.24	
10	5/10/2008	15:00	538.2	
11	5/10/2008	14:00	546.48	
12	5/10/2008	13:00	552	
13	5/10/2008	12:00	579.6	
14	5/10/2008	11:00	590.64	
15	5/10/2008	10:00	598.92	
16	5/10/2008	9:00	612.72	
17	5/10/2008	8:00	582.36	
18	5/10/2008	7:00	576.84	
19	5/10/2008	6:00	571.32	
20	5/10/2008	5:00	524.4	
21	5/10/2008	4:00	532.68	
22	5/10/2008	3:00	549.24	
23	5/10/2008	2:00	565.8	
24	5/10/2008	1:00	554.76	

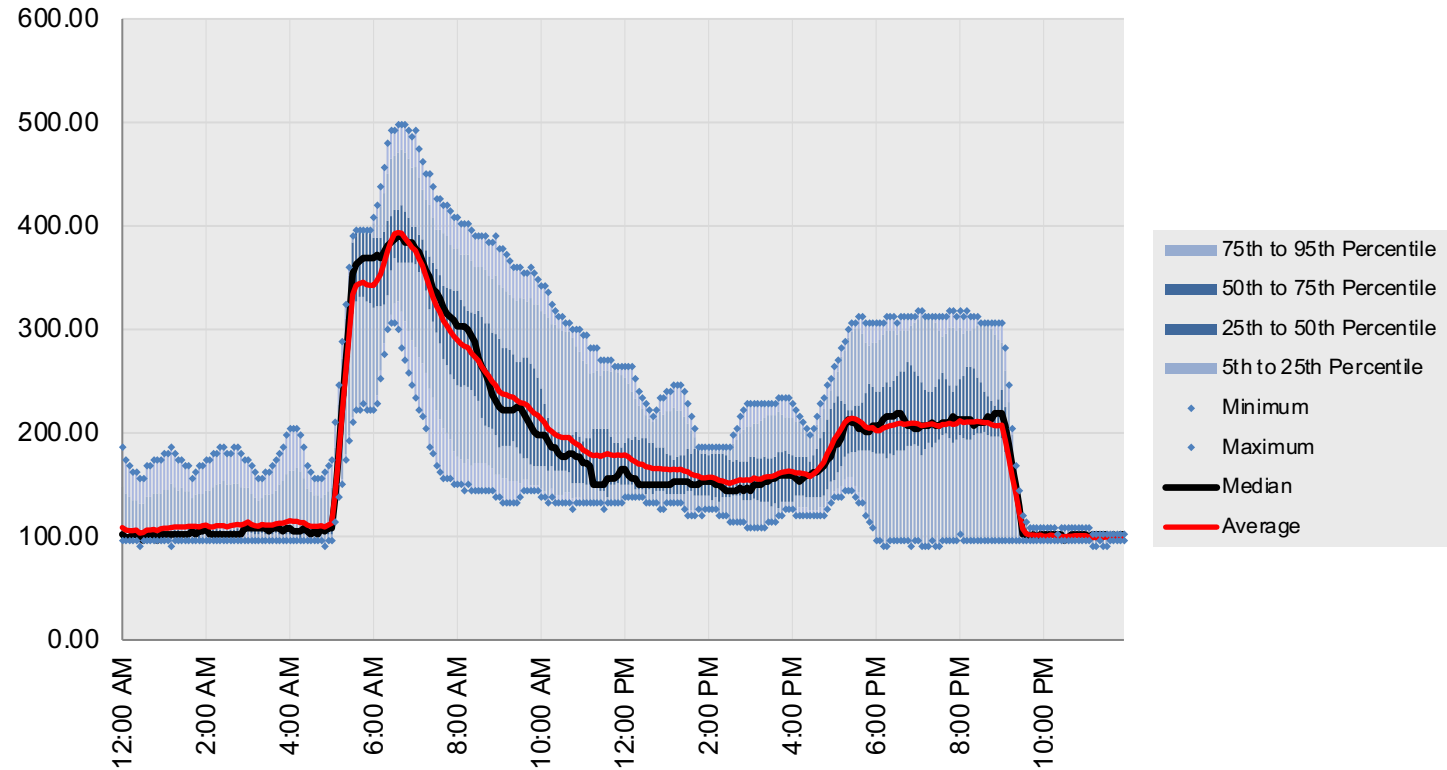
Meter Data Analysis

Load Profile by Day Type



Meter Data Analysis

Load Profile as Box Plots



Detailed: Sub-Metered Data



PowerScout 3 HD Power Submeter

The PowerScout 3 HD is the latest model in the HD family replacing the PowerScout 3037 as DENT



PowerScout 12 HD Multi-Circuit Power Submeter

The PowerScout 12 HD by DENT Instruments is



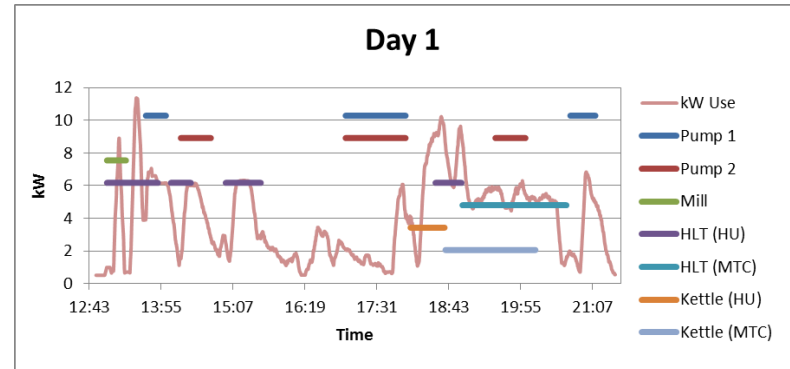
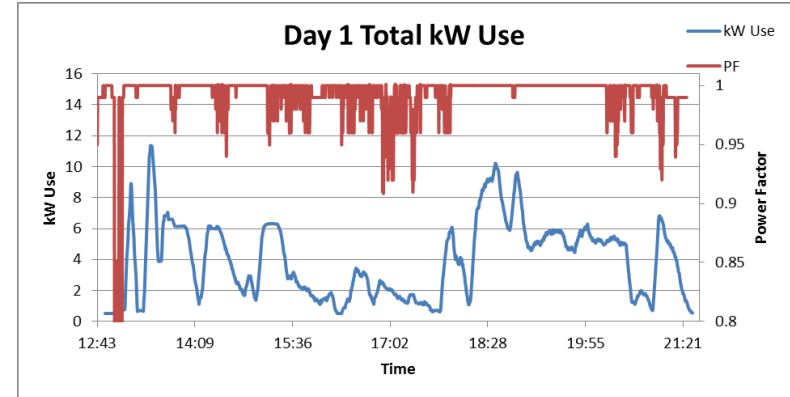
PowerScout 24 HD Multi-Circuit Power Submeter

The PowerScout 48 HD is a first-of-its-kind,

Sub-Metered Data Analysis

GIS Low Cost Energy Sensor

- Logged all equipment at a single point
- Used, recipe, power, and power factor to disaggregate power by device
- Found energy waste during brewing process
- Made process and equipment recommendations



Other Monitored Data

- **HVAC System Temperatures, and operating conditions**
 - Outdoor Air Temperature
 - Outdoor Air %RH
 - Return Air Temperature
 - Supply Air Temperature
 - Outdoor Air Damper Position
 - Mixed Air Damper Position

Thank You

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RIT



Cornell CALS
College of Agriculture and Life Sciences



Rensselaer

Funding provided by the State of New York. ©2021 Rochester Institute of Technology. Any opinions, findings, conclusions, or recommendations expressed are those of Rochester Institute of Technology and its NYS Pollution Prevention Institute and do not necessarily reflect the views of New York State.

Glenstone Museum

A Case Study in Energy Monitoring

Energy Monitoring for Cultural Heritage Institutions
February 19, 2021

Glenstone

1



2



Ellsworth Kelly, *Untitled*, 1996 and *Spectrum IX*, 2014



Robert Gober, *Untitled*, 1992



Charles Ray, *Second Installation*



Tony Smith, *Smug*, 1973/2005

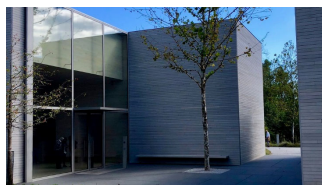


Eva Hesse, Richard Serra, and Alan Saret, *Room 2 Installation*



Pipilotti Rist, *Ever is Over All*, 1997

3



Arrival Hall



Cafe



Environmental Center



Gallery



Patio



Pavilions

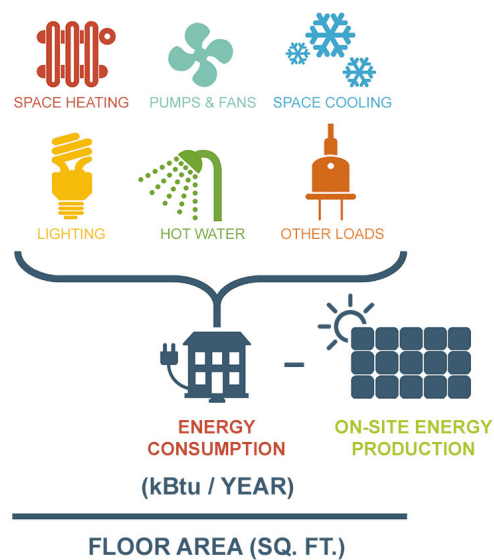


4

We define success in terms of decades not years. We are committed to preservation and sustainability in everything we do.

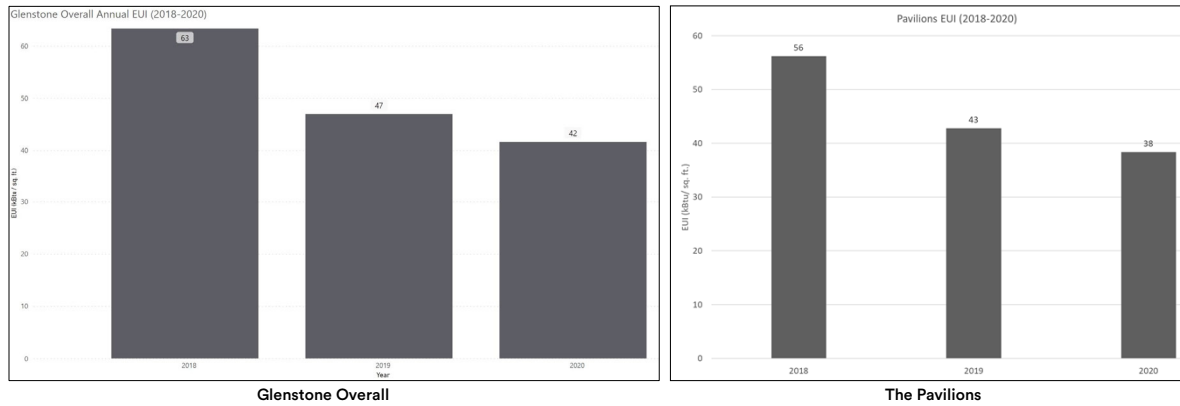
5

Site Energy Use Intensity (EUI)



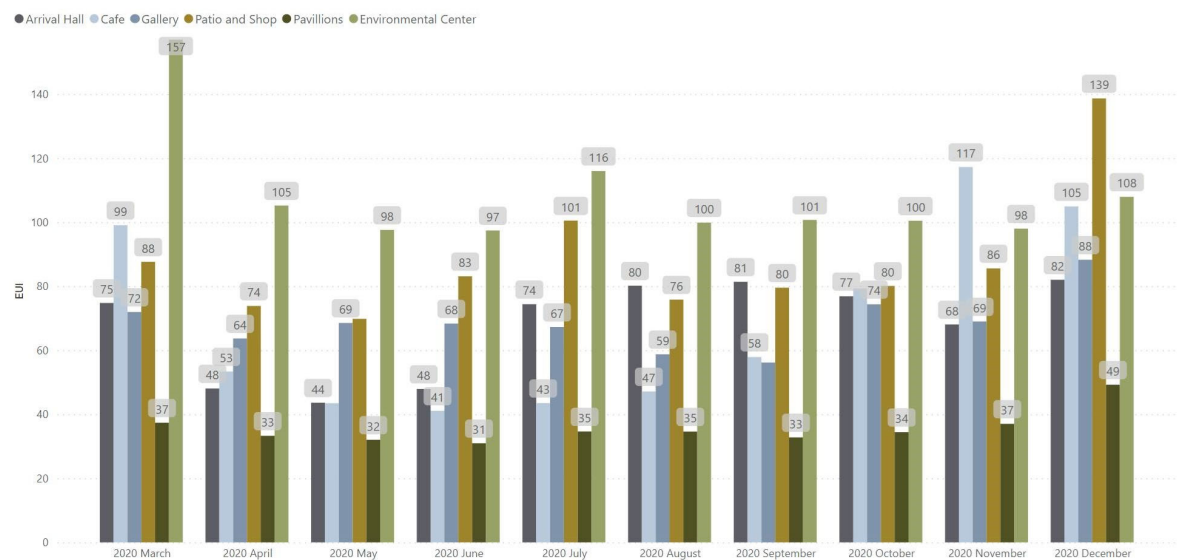
6

Overall EUI (2018-2020)



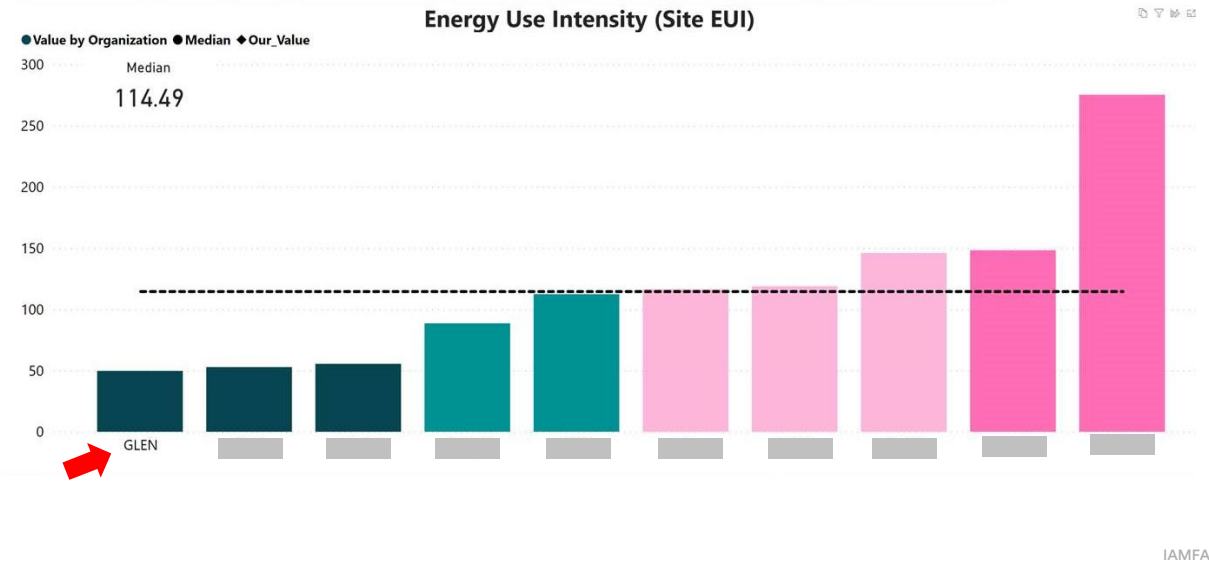
7

EUI by Building (2020)



8

EUI by Museum (2020)



9

Goals



LEED status (left) and the Pavilions (right)

10

Energy metering



Electrical meter (left), water meters (center), and bank of meters (right)

11

Energy monitoring



DOAP AHU Details - Seasonal													
UNIT NAME	VALVE POSITION	COOLING			LAST CALL	VALVE POSITION	HUMIDIFYING			SIGNAL FROM PID	DEHUMIDIFYING		
		RUN TIME	RUN VOLUME				RUN TIME	RUN VOLUME	LAST CALL		RUN TIME	RUN VOLUME	LAST CALL
AH-G-2A	43 %	906	325	0	0 %	1536	485	3432	0 %	120	21	677	
AH-G-2B	4 %	042	220	4	0 %	1539	505	3432	0 %	122	21	677	
AH-G-3.4	0 %	1045	301	9	0 %	273	76	3366	0 %	181	24	672	
AH-G-6	9 %	76	24	0	0 %	0	0	470	0 %	94	13	1	
AH-G-7.8.9	0 %	41	40	0	0 %	0	0	469	0 %	2	0	67	
AH-G-10.11	0 %	1008	179	6	0 %	0	0	1341	0 %	134	33	657	
AH-S-AUX	0 %	2195	700	5	0 %	1275	200	2399	32 %	3390	828	0	
AH-S-N	100 %	644	650	0	0 %	0	0	1330	38 %	1083	379	0	
AH-S-S	0 %	56	11	1501	0 %	0	0	1834	Off	0	0	1840	
AH-S-C	0 %	783	309	1	0 %	1639	413	1956	43 %	1113	334	0	
AH-G-E	0 %	2208	906	12	0 %	1761	604	1952	0 %	220	177	19	
AH-L-NE	0 %	209	205	0	0 %	0	0	1336	0 %	355	136	0	
AH-L-NW	76 %	331	222	0	0 %	0	0	469	0 %	0	0	382	
AH-L-SE	100 %	2668	1348	0	0 %	347	145	3435	0 %	178	49	12	
AH-L-SW	100 %	198	139	0	0 %	0	0	468	36 %	120	41	0	
AH-A-1	42 %	464	154	0	0 %	0	0	1346	0 %	108	9	112	
AH-A-2	30 %	1209	680	0	0 %	0	0	1824	Off	506	0	26	
AH-A-3	23 %	7502	1361	0	0 %	1062	400	3922	0 %	248	73	627	
AH-A-4	29 %	6127	1641	0					Off	0	0	6171	
AH-A-5	0 %	5	5	1					Off	0	0	6183	
AH-A-6	0 %	3116	615	707					Off	0	0	8192	
AH-A-7	23 %	997	670	0	0 %	0	0	1829	Off	569	0	7	

Controls engineer doing daily building health check (left) and building management system dashboard (right)

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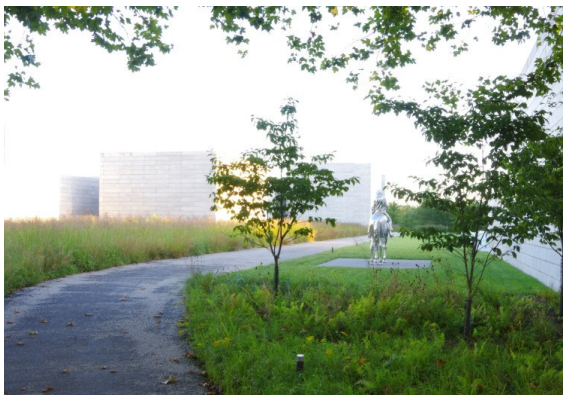
Energy conservation measures



Mechanical system in the Pavilions

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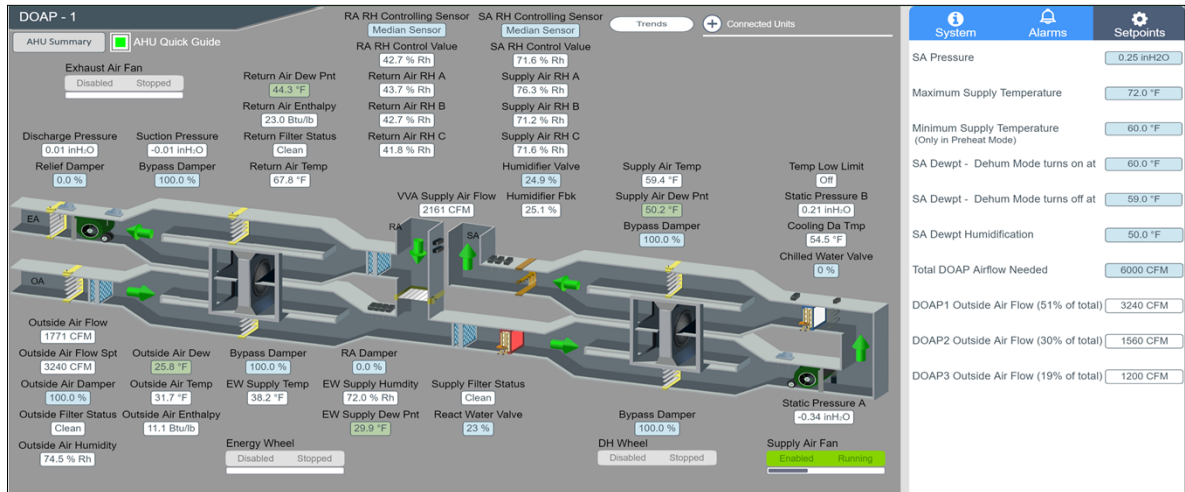
Environment



The Pavilions in summer and in winter

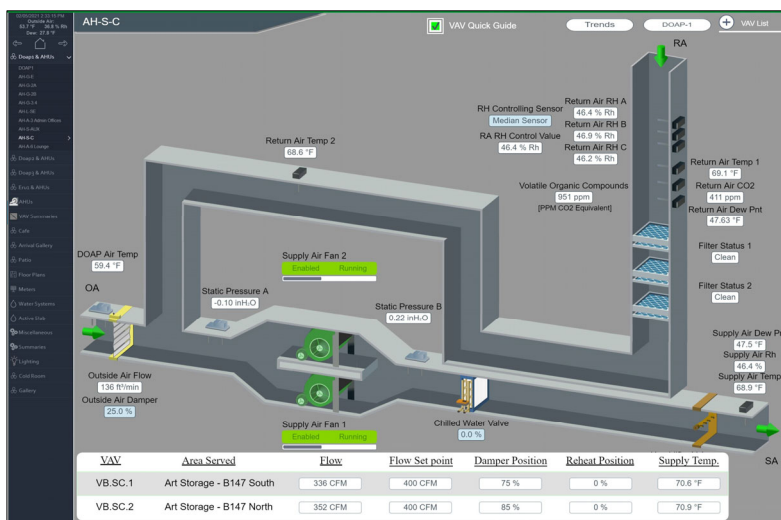
14

Environmental parameters



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Variable air volume



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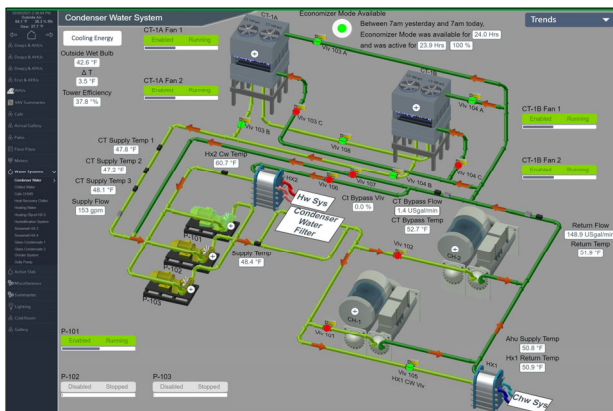
Boilers and steam grid



Boiler system (left and center) and steam grid (right)

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Motor speeds



Building management system screen showing the condenser water system (left) and cooling towers of the Pavilions (right)

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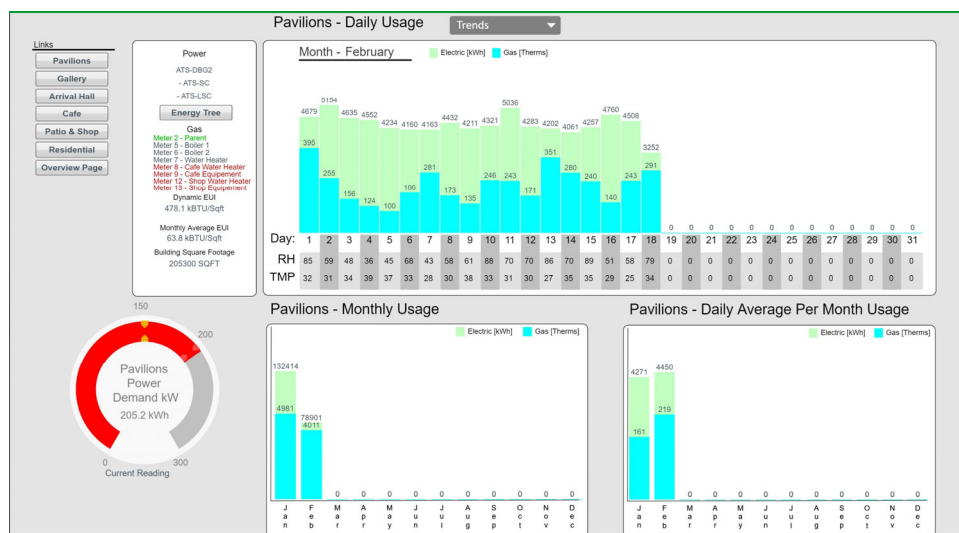
Looking forward



Bifold doors at the Environmental Center (left) and non-condensing boilers at the Gallery (right)

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Trends



Building management system screen showing trends

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Continuous Improvement



Director of Engineering and Maintenance describing changes (left) and the Pavilions (right)

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Thank you

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Image credits

Slide 2: Aerial of the Pavilions. Photo: PWP Landscape Architecture. Courtesy: Glenstone Museum

Slide 3: Room 2 installation. Eva Hesse, *Several*, 1965. Artworks by Richard Serra: *White Neon Belt Piece*, 1967, and *To Lift*, 1967. Alan Saret, *Four Piece Folding Glade*, 1970 © The Estate of Eva Hesse. Courtesy Hauser & Wirth; © 2018 Richard Serra / Artists Rights Society (ARS), New York; © 2018 Alan Saret. Photo: Ron Amstutz. Courtesy: Glenstone Museum.; Tony Smith, *Smug*, 1973/2005. aluminum, painted black. 11 x 78 x 64 feet (3 x 24 x 20 m). © 2018 Estate of Tony Smith / Artists Rights Society (ARS), New York. Photo: Iwan Baan. Courtesy: Glenstone Museum

Slide 4: Potomac Construction Services. <http://www.pcsgc.com/specialty/other/glenstone-foundation-cafe-and-patio-potomac-md/>. ; <https://commons.wikimedia.org/wiki/File:Glenstone-2018-10-24-exterior-cafe.jpg>

Slide 6: Figure by Daniel Overbey. <https://www.buildingenclosureonline.com/blogs/14-the-be-blog/post/87007-energy-use-intensity-eui-in-simple-terms>

All other images are courtesy of Glenstone Museum.