Lessons Learned: Training Engineering Students with Building EQ

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Outlines

I. Background and Introduction

II. A Case Study for Brevard Public Schools

III. ASHRAE Building Energy Quotient: Lessons Learned

IV. Conclusions and Future Plans

Learning Objectives

- Provide an overview of how the Building EQ Portal is utilized on facility projects.
- Understand the application of the Building EQ assessment process in education facility and campus settings.
- Communicate the value of utilizing the Building EQ program for improving the energy performance of educational facilities.
- Identify the value of Building EQ as a training tool for ASHRAE professionals to teach students how to conduct energy audits.

I. Introduction: Florida Tech's ASHRAE Student Branch

Florida Tech. ASHRAE Student Branch Activities

1. Research Projects
2. Senior Design Projects
3. Hosting presentations
4. Encourage and support students to attend conferences
5. Support students with scholarship opportunities
6. **Students Training and Community Services:**
   - K-12 Schools Energy Audits in Collaboration with Brevard Public Schools (BPS)

Acknowledgments

✓ **Brevard Public Schools:**
- ✓ Sue Hann, Assistant Superintendent Facilities Services
- ✓ Bruce Lindsay, Manager, Energy and Resource Conservation
- ✓ Joseph Montemurno and Charles Mcmahon

✓ **ASHRAE Building EQ Committee**
- ✓ John Constantinide, Sr. Mechanical Engineer Alpha MRC

✓ **Florida Tech's ASHRAE Student Branch Students:**
- ✓ Ganesh Doiphode, Obinna Uyanna, Bhaskar Aggarwal, Tejas Thakur, Mariana Migliori

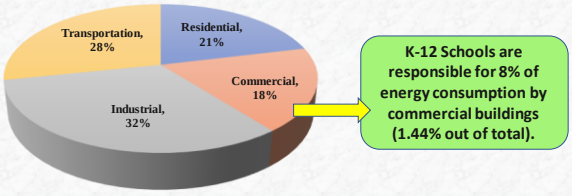
I. Introduction: Collaboration with BPS

✓ Established a collaboration with BPS in January 2019

✓ **Objectives**:
- ✓ Information empowering the school district that leads to a more sustainable future
- ✓ Provide hands on experience for engineering students
- ✓ Motivate and train students to pursue an energy related career
- ✓ Provide service to the community
- ✓ Enhance student engagement in ASHRAE activities

I. Introduction: Why It Matters?!

- U.S. energy consumption is about 101.3 quadrillion Btu, equal to 18% of world total energy consumption.



US Energy information Administration, Monthly Energy Review, April 2019 (https://www.eia.gov/energyexplained/use-of-energy/)

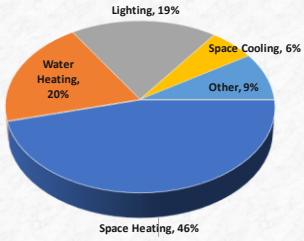
II. A Case Study in Brevard Public Schools

- ✓ A team of five students participated in the pilot program
- ✓ Three school audits were performed: Meadowlane Primary, Meadowlane Intermediate and Central Middle as well as the Chiller Plant (April 2019)
- ✓ The students participated in the audits and collected data under supervision of BPS staff
- ✓ The students maintained regular meetings with the faculty advisor over the summer and worked on the report.

I. Introduction: Why It Matters?!

- 125,000 K-12 schools in the U.S spend $8 billion each year on energy.

- According to the U.S. DOE, at least a quarter of that could be saved through smarter energy management.



https://www.forbes.com/sites/uxenergy/2017/09/27/cutting-energy-use-is-one-way-cash-strapped-schools-can-save-but-by-how-much/#2aee072cb21
https://meetingoftheminds.org/energy-efficiency-solar-8-billion-school-energy-market-24242

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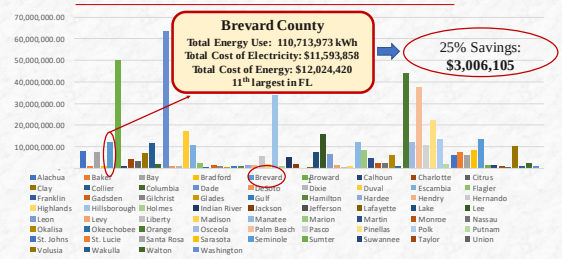
- **Pre-Audit:**
  - ✓ Developed a questionnaire according to prior experiences and ASHRAE Building EQ requirements
  - ✓ Meeting with BPS staff and discussed audit procedure
- **During Audit:**
  - ✓ Collected data on Energy and IEQ: light counts and light level, temperature and RH, CO_2 concentration, name plate information of major end users, etc.
  - ✓ Collected basic data: schedule of operation, square footage, number of occupants, etc.
- **Post-Audit:**
  - ✓ Weekly meetings
  - ✓ Detailed bill analysis
  - ✓ Performed data analysis and completed inputs to ASHRAE Building EQ for Level 1 Report
  - ✓ Completed a report with detailed baseline energy analysis and EEM evaluations

I. Introduction: Why It Matters?!



http://www.fldoe.org/core/fileparse.php/5599/urlt/1718AnnualEnergy.pdf

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	Meadowlane Primary	Meadowlane Intermediate	Central middle
Built year	1987	2007	-
Gross Floor Area (sq. ft)	96,778	121,348	199,214
Population (student + staff)	900-1000	1000-1100	1100-1200
Operating hours	M-F: 7:30AM to 3:30 PM	M-F: 7:30AM to 3:30 PM	M-F: 8:30AM to 4:30 PM
FPL Rate Structure	SDTR-1A	SDTR-1A	SDTR-2A

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- **Best Practices**

- A default set-point cooling temperature of 76°F is in use
- The chillers are equipped with variable frequency drive (VFD) control
- The chilled water pipes are well-insulated
- The chillers are off during the unoccupied hours.
- The windows installed in the school are tinted which reduces the building cooling load.
- Light color roof used for two of the schools reduces the cooling load

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- **Bill Analysis-Main Meter: Summary of Energy Usage and Rates**

	Meadowlane Primary	Meadowlane Intermediate	Central middle	Chiller
Energy usage in 2018 (kWh/yr)	564,480	640,800	1,146,800	1,662,400
Usage rate ($/kWh)	0.0485	0.0482	0.0391	0.0443
Demand rate ($/kW)	9.203	9.298	11.451	11.073
TSI rate (%)	7.27	13.05	10.08	7.64

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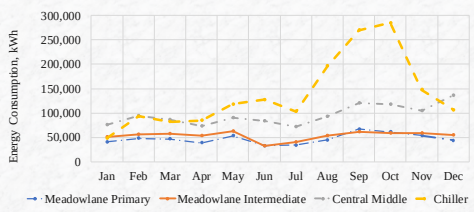
- **Bill Analysis-Main Meter: Monthly Energy Consumption**



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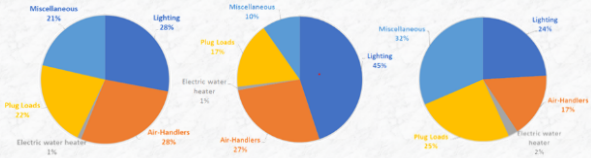
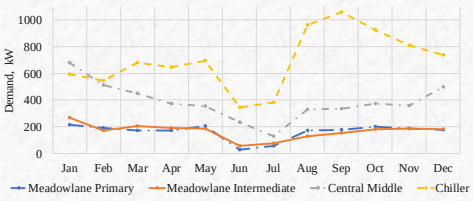
- **End-Use Energy Estimate**



Meadowlane Primary | **Meadowlane Intermediate** | **Central middle**

II. A Case Study in Brevard Public Schools

- **Bill Analysis-Main Meter: Monthly Demand Data**



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- **Assessment Recommendations (ARs)**

Lighting:

AR 1-Replace T8 Lights with LEDs

AR 2- Install Occupancy Sensors

AR 3- Replace Security Lights with LEDs and Install Photosensors

HVAC:

AR 4- Install Ice Storage Tanks

On-Site Electricity Generation:

AR 5 - Install Rooftop Photovoltaic Panels

Evaluated:
Energy Savings - Demand Savings - Cost Savings - Implementation Cost – Simple Payback Period

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II. A Case Study in Brevard Public Schools

- **AR-1: Replace T8 Lights with LEDs**

✓ Replace the existing T8 lights with energy efficient 12 W LED light bulbs that offers equivalent light output with a much smaller energy use

	Meadowlane Primary	Meadowlane Intermediate	Central middle
Energy Savings (kWh/yr)	76,214	161,381	145,463
Demand Savings (kW/yr)	424	898	810
Total cost savings ($/yr)	8,150	17,306	17,052
Implementation cost ($)	14,778	31,294	28,208
Payback Period (years)	1.8	1.8	1.7

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II. A Case Study in Brevard Public Schools

- **AR-2: Install Occupancy Sensors**

✓ Install occupancy sensors in areas with intermittent schedules

	Meadowlane Primary	Meadowlane Intermediate	Central middle
Energy Savings (kWh/yr)	13,874	23,502	21,184
Total cost savings ($/yr)	722	1,216	999
Implementation cost ($)	3,015	4,523	5,654
Payback Period (years)	4.2	3.7	5.7

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II. A Case Study in Brevard Public Schools

AR-3: Replace Security Lights with LEDs and Install Photosensors

✓ Replace existing lights with 9.5W LEDs with equivalent lumens and install a photo sensor to turn the lights on only when the outdoor light level is low

	Meadowlane Primary	Meadowlane Intermediate	Central middle
Energy Savings (kWh/yr)	23,090	34,635	48,478
Demand Savings (kW/yr)	30	45	73
Total cost savings ($/yr)	1,497	2,245	3,201
Implementation cost ($)	717	394	578
Payback Period (years)	0.5	0.18	0.2

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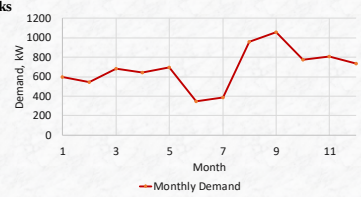
AR-4: Install Ice Storage Tanks

Baseline:
- ✓ Two 650 chillers
- ✓ Monthly demand is demonstrated



✓ Local utility offers a significant rebate for shifting the demands to off-peak hours ($600/kW)
✓ The rate schedule will change to SDTR2-B (as a substitute for SDTR2-A).

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II. A Case Study in Brevard Public Schools

AR-4: Install Ice Storage Tanks

Items	Cost ($)
47 – Ice Tanks + installation ($18,000/unit)	$846,000
Heat exchanger	$50,000
Piping (Estimated 6" at 1000 feet @ $100 per foot)	$100,000
Added Building Automation Controls	$15,000
Other costs	$15,000

Total Cost Savings ($/yr)	Utility Rebate ($)	Implementation Cost ($)	Payback Period (yrs)
$94,316	$405,504	1,026,000	6.6

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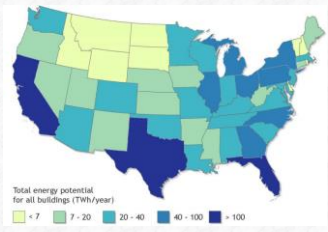
AR-5: Install Rooftop Photovoltaic Panels

- The Sunshine State is ranked 3rd in the country in terms of potential of using roof-top PV
- Florida is ranked 14th in terms of using rooftop PVs
- Renewable source, reduced carbon foot print and resilient against natural disasters!



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II. A Case Study in Brevard Public Schools

AR-5: Install Rooftop Photovoltaic Panels

- Install rooftop PVs to produce ~50% of energy requirements for the school buildings
- Simulation was performed in System Advisor Model (SAM)

Entity	Meadowlane Primary	Meadowlane Intermediate	Central Middle
System nameplate size (kWdc)	150	160	290
Annual Energy (kWh)	294,870	314,528	570,082
Bill Without System ($)	48,374	54,853	98,073
Bill with System ($)	29,628	34,686	61,729
Net Savings ($)	18,746	20,167	36,344
Implementation Cost ($)	291,160	310,164	562,816
Payback Period (yrs)	13.3	13.1	13.2

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II. A Case Study in Brevard Public Schools

- **Summary of Findings**

AR 1-3 collectively result in 547,821 kWh savings for the 3 schools which is about 23.2% of total energy consumption

		Energy Savings (kW/yr)	Demand Savings (kW/yr)	Total cost savings ($/yr)	Implementation cost ($)	Payback Period (years)
Meadowlane Primary	AR-1	76,214	424	8,150	14,778	1.8
	AR-2	13,874		722	3,015	4.2
	AR-3	23,090	30	1,497	717	0.5
	Total	**113,178**	**454**	**10,369**	**18,510**	**1.8**
Meadowlane Intermediate	AR-1	161,381	898	17,306	31,294	1.8
	AR-2	23,502		1,216	4,523	3.7
	AR-3	34,635	45	2,245	394	0.18
	Total	**219,518**	**943**	**20,767**	**36,211**	**1.7**
Central Middle	AR-1	145,463	810	17,052	17,052	1.7
	AR-2	21,184		999	5,654	5.7
	AR-3	48,478	73	3,201	578	0.2
	Total	**215,125**	**883**	**21,252**	**23,284**	**1.1**

AR-4

Total Cost Savings ($/yr)	Total Rebate ($)	Implementation Cost ($)	Payback Period (yrs)
$94,316	$405,504	1,026,000	6.6

AR-5

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Overall, implementing the five recommendations will result in an overall payback period of 8.4 years!

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III. ASHRAE Building EQ: Lessons Learned

- **What is Building EQ?**

✓ A web portal developed by ASHRAE to facilitate the ASHRAE Level 1 Audit

✓ Convenient data entry and automatic calculation of EUI

✓ Allows in operation and as designed modes

✓ Generates reports as word documents and summary of inputs/outputs as spreadsheets

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III. ASHRAE Building EQ: Lessons Learned

- **Building EQ as an Educational Tool**

✓ Allows educators to train students for performing a systematic energy audit

✓ The inputs are demonstrated in an organized fashion and can be used as a reference for preparing questionnaires

✓ Offers a strong user manual that is comprehensive and easy to use

✓ Allows collaborative work through the online portal

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III. ASHRAE Building EQ: Lessons Learned

- **Building EQ as an Audit Tool**

✓ Conveniently available through the web and allow multiple users access

✓ Can serve as an excellent database for end users such as schools for keeping the track of historical data and energy/IEQ performance.

✓ Allows rating buildings both as In Operation and As Designed modes

✓ Generates well-organized reports in accordance with ASHRAE Level 1 energy audit requirements

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III. ASHRAE Building EQ: Lessons Learned

- **Improvement Opportunities:**

✓ Florida Tech's Team identified multiple improvement opportunities and already sent those to the ASHRAE Building EQ Committee.

✓ Several of our recommendations are considered by the ASHRAE Building EQ committee for future releases

✓ The recommendations are mostly focused on:
- ✓ developing a more dynamic and interactive environment for the end-user
- ✓ allow more flexibility for inputs
- ✓ Provide additional options for more detailed outputs

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IV. Conclusions and Future Works

- **Conclusions:**

✓ A collaborative effort between Florida Tech and BPS was established to allow information empowering of the school district and provide hands on experience for students to serve the community.

✓ The pilot program was successfully completed with five students participants and three schools.

✓ Significant energy savings opportunities were identified for the schools under this study and a procedure for future analysis was established

✓ ASHRAE Building EQ was used as an effective tool for students training and energy audit.

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IV. Conclusions and Future Works

- **Future works:**

✓ New schools with similar design and different energy usage are identified to be further studied

✓ Multiple sustainability projects are defined to perform energy audits on commercial buildings

✓ Several research opportunities have been identified. If funding becomes available, major studies can be performed on energy and IEQ for schools

✓ Building EQ will be incorporated in undergraduate engineering courses

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Questions?

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