

Ferguson Township Elementary School and the Energy Model

Introduction

The Ferguson Township Elementary School is located in State College, PA. The proposed renovation and addition consists of a 2 story, 60,600 sq ft addition and renovations to 14,300 sq ft of the existing school. The model includes approximately 10,600 sq ft of unconditioned crawl space and 3,700 sq ft mechanical space in the existing building. The cost per square foot in the comparative table is based upon 64,300 sq ft of conditioned area. The purpose of this energy modeling analysis is to evaluate various energy efficiency measures (EEMs) that would optimize the building's energy performance. Some of these EEMs would reduce the building loads, thereby reducing the size of the HVAC equipment needed, while others address optimizing the HVAC systems.

The baseline envelope in this analysis uses the minimum ASHRAE 90.1-2007 envelope requirements for the addition and the existing building is modeled as is with single-pane steel framed windows and constructions as described by the architect. This model uses an air-cooled chiller and a natural gas hot water boiler to condition the building. There are assumed to be unit ventilators in each zone and a packaged single-zone rooftop unit serving the Multi-Purpose Room.

Energy Model Descriptions

In accordance with LEED EA Credit 1 Optimize Energy Performance, the Baseline energy model for Ferguson Township Elementary School was developed during the schematic design process using a 4-pipe system with air-cooled chiller and gas-fired boiler serving unit ventilators in each space, except the Multi-Purpose Room which is served by a packaged rooftop unit with DX cooling and hot water heat as the HVAC system and ASHRAE 90.1-2007 Performance Rating Method and BER Table 5 and industry standards. Since natural gas is not available on this site, LP Gas is used as the principal heating fuel. Certain process loads are omitted from the models including, but not necessarily limited to elevators, cooking, refrigeration, and exterior lighting. Each classroom is assumed to have 20 occupants and occupancy for other space is determined based upon the default occupant densities from ASHRAE 62.1-2007. In the absence of system operational parameters, the Appendix G operating characteristics described in Section G3.1.3 are applied. Weather data is located in the TMY file for State College, PA. Generally, the instructional and ancillary spaces are assumed to be occupied weekdays from 8 am to 3 pm during the school year and the offices are occupied from 8 am until 5 pm through out the year. Energy Opportunities, Inc. created these models using eQuest v3.60.

Energy Efficiency Measures (EEMs)

The Ferguson Township Elementary School energy model analysis evaluates a number of EEMs to minimize energy use in the building. These EEMs listed below are evaluated independently and collectively using the baseline HVAC system. The alternate HVAC system runs use the combination of all EEMs. The details for each EEM can be found in the attached "Building Energy Enduse Summary".

Regulated Measures

- EEM 1 - Increased Roof Insulation to R30 and overall Wall Insulation to R25 (initial envelope performance specified)
- EEM 2 - Improved windows ($U=0.25$, $SHGC=0.25$, $Vlt=0.6$)
- EEM 3 - Interior lighting reduced to 0.75 W/sqft
- EEM 4 - Daylight dimming controls with reduced lighting power (EEM3)
- EEM 5 - Combination Run - EEM1 through EEM4
- EEM 6 - Packaged Variable Air Volume (VAV) Units with hot water reheat
- EEM 7 - Variable Refrigerant Volume (VRV) System with energy recovery for ventilation air
- EEM 8 - Ground-source heat pumps with energy recovery for ventilation air

Ferguson Twonship Elementary School
eQuest v3.6 Modeling Results Summary

Building Energy Enduse Summary for Individual Energy Efficiency Measures (EEMs)

Individual EEM Design Runs	Baseline	EEM 1 R30 Roof & R25 Walls	EEM 2 Windows	EEM 3 0.75 W/sqft LPD	EEM 4 LPD & Daylighting	EEM 5 EEM 1-4 Combination	EEM 6 VAV Units	EEM 7 VRV System	EEM 8 GSHP
Estimated Operating Costs									
Electric	\$34,056	\$32,562	\$30,482	\$26,343	\$23,163	\$18,323	\$18,265	\$47,626	\$39,326
LP Gas	\$96,357	\$83,148	\$84,295	\$100,058	\$101,682	\$76,631	\$89,858	\$3,166	\$3,164
Total	\$130,413	\$115,710	\$114,777	\$126,401	\$124,845	\$94,954	\$108,123	\$50,792	\$42,490
Cost/SqFt	\$2.03	\$1.80	\$1.79	\$1.97	\$1.94	\$1.48	\$1.68	\$0.79	\$0.66
Building Energy Use (MBtus)									
Electric (MBtu)	984.4	938.3	883.4	760.8	675.3	530.6	511.0	1,428.3	1,287.5
LP Gas (MBtu)	4,510.8	3,892.4	3,946.1	4,684.8	4,760.1	3,587.4	4,206.6	148.2	148.1
Total (MBtu)	5,495.2	4,830.7	4,829.5	5,445.6	5,435.4	4,118.0	4,717.6	1,576.5	1,435.6
Consumption									
Site (kBtu / SqFt / Yr)	77.7	68.3	68.2	76.9	76.8	58.2	66.7	22.3	20.3
Source (kBtu / SqFt / Yr)	105.5	94.8	93.2	98.4	95.9	73.2	81.1	62.6	56.7
Building Electric Use (kWh)									
Lights	162,643	162,643	162,643	101,652	78,939	79,023	79,023	79,023	79,023
Task Lights	0	0	0	0	0	0	0	0	0
Misc. Equip.	23,579	23,579	23,579	23,579	23,579	23,579	23,579	23,579	23,579
Space Heat	0	0	0	0	0	0	0	185,014	176,600
Space Cool	26,147	23,703	16,071	23,402	22,148	10,101	17,117	3,067	2,005
Heat Rejection	0	0	0	0	0	0	0	0	0
Pumps & Aux.	17,342	15,453	12,969	16,445	16,053	9,790	6,131	7,082	48,197
Ventilation Fans	58,726	49,553	43,559	57,828	57,145	32,967	23,871	25,453	47,847
Refrig Display	0	0	0	0	0	0	0	0	0
Ht Pump Supplement	0	0	0	0	0	0	0	95,280	0
Total	288,437	274,931	258,821	222,906	197,864	155,460	149,721	418,498	377,251
Building LP Gas Use (Gallons)									
Space Heat	45,691	39,215	39,774	47,503	48,299	36,012	42,504	0	0
Domestic Hot Water	1,543	1,544	1,547	1,545	1,545	1,552	1,544	1,552	1,551
Total	47,234	40,759	41,321	49,048	49,844	37,564	44,048	1,552	1,551
Sum of Building Space Peak Loads (without Ventilation)									
Heating (kBtu/h)	1,141.8	944.5	903.9	1,151.3	1,146.2	719.5	719.5	719.5	719.5
Cooling (kBtu/h)	877.5	767.8	717.0	813.3	759.5	486.7	486.7	486.7	486.7
Cooling (Tons)	73	64	60	68	63	41	41	41	41
EEM Economics									
EEM Savings	NA	\$14,703	\$15,637	\$4,012	\$5,569	\$35,460	\$22,290	\$79,621	\$87,923
EEM Costs	NA	(in base cost)		-\$90,020	\$57,870		see Life Cost Cycle Analysis		
Payback	NA	NA	0.00	Immediate	10.39		see Life Cost Cycle Analysis		

EEM Descriptions See "Project Narrative"