Final Technical Report
Thundering Buffalo Health and Wellness Center

Recipient Organization: Assiniboine & Sioux Tribes of the Fort Peck Indian Reservation

Project Title: Thundering Buffalo Health and Wellness Center

Date of Report: 6-13-2023

Award Number: DE-FOA-0002032

Total Project Costs: $676,982

DOE Share: $609,283

Recipient Cost Share: $67,699

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Associated Construction Engineering, Inc - Todd Meling, PE
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ACKNOWLEDGMENT

This material is based upon work supported by the Department of Energy, Office of Indian Energy Policy and Programs, under Award Number *DE-FOA-0002032*.

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Executive Summary

This U.S. Department of Energy, Office of Indian Energy supported project consists of energy conservation measures (ECMs) and a solar photovoltaic (PV) system to reduce cost of utility bills in a newly constructed Fort Peck Wellness Center, for use by tribal members in improving their physical and mental wellness. Construction of the building was outside the scope of the DOE supported project. A new 2-story wellness center was designed and constructed in Poplar, Montana. The wellness center is comprised of fitness areas, gymnasium, pool and spa, offices, and BOH support areas.

The project was eligible to apply for the Energy Infrastructure Deployment on Tribal Lands Funding Opportunity 2019 (FOA Number DE-FOA-0002032). As part of the application, the project conducted a design analysis to evaluate various energy efficient designs for the envelope, lighting, HVAC, and process loads. This process was completed in 2019 and a grant was approved. The building was completed and has been operational for more than a year. A final measurement and verification of energy savings was completed after one year of operation and the results are presented herein, showing an energy savings 20% higher than the originally models indicated.

The project team had several objectives:

A. ENERGY OBJECTIVES

The Fort Peck Tribe set the following energy goals and objectives:
Primary Goals:

- *Affordable*
- *Sustainable*
- *Cost Effective*
- *Minimize staff requirements*

Secondary Objectives: Options that support the following requirements are preferred by the Tribe:

- *Education*
- *Minimize staff requirements*

B. SPECIFIC PROJECT GOALS

- *Provide onsite energy generation of 50 kW.*
- *Provide energy efficiency measures reducing energy costs by 27% over the local enforced energy code (2012 International Energy Conservation Code).*

Exciting news -The goals have been achieved! The building was built and is exceeding the energy goals set. The PV system is operational and is reducing utility energy consumption. These goals have led to reduced utility infrastructure required for this facility.

Background

Assiniboine & Sioux Tribes of the Fort Peck Indian Reservation are a federally recognized Tribe located in the Northeastern corner of Montana approximately 40 miles south of the Canadian border and 60 miles west of the North Dakota border. As of January 29, 2019, the total number of enrolled members living on the Reservation is 6,785. An additional 360 live adjacent to the Reservation. The total Tribal membership is 13,238. The Reservation is approximately 2.1 million acres in size and its' exterior boundaries overlap the counties of Roosevelt, Valley, Sheridan, and Daniels with 6 communities spanning the southern border. The Tribal Council is comprised of 12 At-Large- Members, a Sergeant-At-Arms, a Vice Chairperson, and a chairperson. All members are elected for 2-year terms with elections held in the odd years. The Fort Peck Tribe's (FPT) have 40 Departments and Offices that provide services to the residents of the Fort Peck Indian Reservation.

One element of the Tribal Vision contained in the FPT 10 Year Strategic Plan is "Model Green Tribal Community" with one of the goals as, "In 2019, the Fort Peck Tribes will be enjoying the benefits of an early investment in a variety of green energy projects." These are: 2009- 2010 30 Ground Source Heat Pumps (GSHP) wells installed on the Adult Correction Center; 2011 8 GSHP installed on Tribal homes across the Reservation; 2012 the Fort Peck Tribes completed a feasibility study funded by the US Department of Energy for Geothermal power production in the Poplar Oil Fields; 2013-2014 the Poplar Cultural Center was rehabilitated to increase the R-value with an energy efficient roof and energy efficient lighting; 2013- 2014 GSHP and energy efficient lighting were installed on the Phase III Tribal Administration Building; 2013-2014 GSHP and energy efficient lighting installed on the Wolf Point Community Hall; 2014 -2015 20 Tribal homes were built using energy efficient building materials and heating/cooling technologies in the Sustainable Village.

The Goal for the WECP is: Invest in the combined installation of energy efficient technologies and power generation within the Wellness Center to further our vision of a Model Green Tribal Community.

Project Objectives

A. ENERGY OBJECTIVES

The Fort Peck Tribe has the following energy goals and objectives:
Primary Goals:

- *Affordable: Provide a low cost of ownership. Provide maintenance friendly and low energy use facilities to allow many years of use at a reasonable cost for maintenance and utilities.*
- *Sustainable: Reduce energy consumption and provide sustainable/renewable energy use and/or generation for a portion of the facility to reduce utility use.*
- *Cost Effective Solutions: Provide systems that are cost effective when considering capital cost and lifetime costs to determine their 25-year life cycle cost.*
- *Minimize staff requirements: Provide a maintenance friendly building that will minimize employee staffing requirements for maintenance and operations for the selected building technologies.*

Secondary Objectives: Options that support the following requirements are preferred by the Tribe:

- *Education: Provide a facility that can highlight its energy efficiency measures and renewable energy systems for public education.*
- *Minimize staff requirements: Provide a maintenance friendly building that will minimize staffing requirements for maintenance and operations.*
- *Replication: Energy efficiency measures that are successful will be replicated.*

B. SPECIFIC PROJECT GOALS

- *Provide onsite energy generation of 50 kW by the 21st Month.*
- *Provide energy efficiency measures reducing energy costs by 23% over the local enforced energy code (2012 International Energy Conservation Code) by the 21st Month.*

Description of Activities Performed

The project design team selection started in 2019. Once the team was selected, the design of the building started. The design process, including conceptual design and schematic design were developed. Then the DOE grant application was submitted. Once that was awarded, the design proceeded with improved envelope and MEP systems, as well as a roof mounted photovoltaic array.

The approach for energy conservation included:

a. Developing a list of multiple Energy Conservation Measures (ECM) for evaluation.
b. Developing construction cost estimates for each ECM.
c. Evaluating the Energy Conservation Measures for a reasonable payback.
d. Selecting acceptable ECM's.
e. Presenting evaluations in the DOE FOA Grant.
f. Receiving Award notification for the DOE FOA Grant.
g. Developing construction documents that include the accepted ECM's.
h. Bidding the project to local contractors.
i. Awarding the project to the contracting team.
j. Attended DOE Grant meetings in Denver, CO.
k. Collecting actual costs for the ECM's.
l. Reviewing proposed equipment, materials and systems involved in the ECM's for compliance with the design intent in the shop drawing approval phase.
m. Construction began. Inspected installed equipment and materials to ensure compliance with DOE Grant ECM's.
n. Construction Completed
o. Attended DOE Grant meetings in Denver, CO.
p. Received energy bills for facility along with hours of operation and did a comparison of energy use vs. modeled energy estimates.
q. Report written.

ECM's successfully pursued (see attached report for more detailed descriptions):

- E1: R-31.6 metal wall panels – improved envelope.
- E2: Improved windows.
- L1: High Performance Lighting.
- M1: High efficiency DX condensing units.
- M2: Condensing hot water boilers for space heating.
- P1: Condensing pool heater.
- P2: Condensing domestic hot water heaters.
- P3: Pool Dehumidification unit heat recovery for pool heating.
- E3: Pool Covers
- Photovoltaic Solar Array.

Conclusions and Recommendations

The project was a huge success in many ways. Specifically, from an energy conservation standpoint, the project exceeded the goal and is operating per design with energy costs lower than originally anticipated and modeled.

The utility cost savings is over 60% higher than anticipated and overall energy savings is around 20% higher than anticipated. The attached report (see Appendix 1) does an in-depth analysis comparing original energy modeling vs. actual utility consumption for the first year of occupancy.

The following table shows the energy savings that the ECM's generated.

Fort Peck Wellness Center Energy Performance										
		Site Energy				Source Energy		Utility Costs		
#	Run	Electric (kWh)	Gas (Therm)	Total MMBtu	EUI (kBtu/ft²)	Total MMBtu	EUI (kBtu/ft²)	Electric ($)	Gas ($)	Total Cost ($)
B-0	IECC 2012 Baseline	743,057	69,970	9,532	183.3	15,308	294.4	$ 80,955	$ 62,973	$ 143,928
E1	R-31.6 Metal Exterior Wall	740,740	68,618	9,389	180.6	15,141	291.2	$ 80,692	$ 61,756	$ 142,448
E2	Design Window GT	739,812	68,371	9,361	180.0	15,105	290.5	$ 80,677	$ 61,534	$ 142,211
L1	Lighting Power Density = 0.68 W/sf	620,663	69,369	9,055	174.1	13,933	267.9	$ 67,848	$ 62,432	$ 130,280
M1	High Efficieny DX AHUs	564,778	66,135	8,541	164.2	12,995	249.9	$ 61,853	$ 59,522	$ 121,375
M2	High Efficiency, Condensing Boilers	574,757	53,858	7,347	141.3	11,813	227.2	$ 62,737	$ 48,472	$ 111,209
P1	High Efficiency Pool Heater	574,757	52,352	7,196	138.4	11,655	224.1	$ 62,737	$ 47,117	$ 109,854
P2	High Efficiency DHW Heater	574,757	51,343	7,095	136.4	11,549	222.1	$ 62,737	$ 46,209	$ 108,946
P3	Dehumidification Heat Recovery for Pool Heating	573,393	45,699	6,526	125.5	10,942	210.4	$ 62,622	$ 41,129	$ 103,751
R1	Solar PV System Generation	498,905	45,699	6,272	120.6	10,144	195.1	$ 57,110	$ 41,129	$ 98,239
Incremental Savings relative to Previous Measure										
E1	R-31.6 Metal Exterior Wall	2,317	1,352	143	2.8	167	3.2	$ 263	$ 1,217	$ 1,480
E2	Design Window GT	928	247	28	0.5	36	0.7	$ 15	$ 222	$ 237
L1	Lighting Power Density = 0.68 W/sf	119,149	(998)	307	5.9	1,172	22.5	$ 12,829	$ (898)	$ 11,931
M1	High Efficieny DX AHUs	55,885	3,234	514	9.9	938	18.0	$ 5,995	$ 2,910	$ 8,905
M2	High Efficiency, Condensing Boilers	(9,979)	12,277	1,194	23.0	1,182	22.7	$ (884)	$ 11,050	$ 10,166
P1	High Efficiency Pool Heater	-	1,506	151	2.9	158	3.0	$ -	$ 1,355	$ 1,355
P2	High Efficiency DHW Heater	-	1,009	101	1.9	106	2.0	$ -	$ 908	$ 908
P3	Dehumidification Heat Recovery for Pool Heating	1,364	5,644	569	10.9	607	11.7	$ 115	$ 5,080	$ 5,195
R1	Solar PV System Generation	74,488	-	254	4.9	798	15.3	$ 5,512	$ -	$ 5,512
Total Savings relative to Baseline										
	Total Savings w/o Solar PV	169,664	24,271	3,006	57.8	4,366	84.0	$ 18,333	$ 21,844	$ 40,177
	Total Percent Savings w/o Solar PV	23%	35%	32%	32%	29%	29%	23%	35%	28%
	Total Savings w/ Solar PV	244,152	24,271	3,260	62.7	5,164	99.3	$ 23,845	$ 21,844	$ 45,689
	Total Percent Savings w/ Solar PV	33%	35%	35%	35%	34%	34%	30%	35%	32%
Savings Comparison to Preliminary Analysis										
	Preliminary Savings w/o Solar PV	177,377	18,951	2,500	48.1	3,890	74.8			$ 25,017
	Actual Savings w/o Solar PV	169,664	24,271	3,006	57.8	4,366	84.0			$ 40,177
	Percent Change from Preliminary Results	-4%	28%	20%	20%	12%	12%			61%

Lessons Learned

Specific challenges that this project saw included the following:

A. The project occurred during COVID which made material delivery and labor availability inconsistent. This added layers of concerns that were all manifested in time problems that had to be dealt with as they presented. Hopefully there will not be a repeat of these concerns for future projects.

B. The local power utility, Montana Dakota Utilities (MDU), had a limit on photovoltaic solar array output of 50 kW. This limited the solar array we could put on the building. The solar array rated kW installed was slightly larger accounting for the sloped roof and impacts of the solar path to maximize the output to the user, but not exceed the utility mandated maximum output of 50 kW.

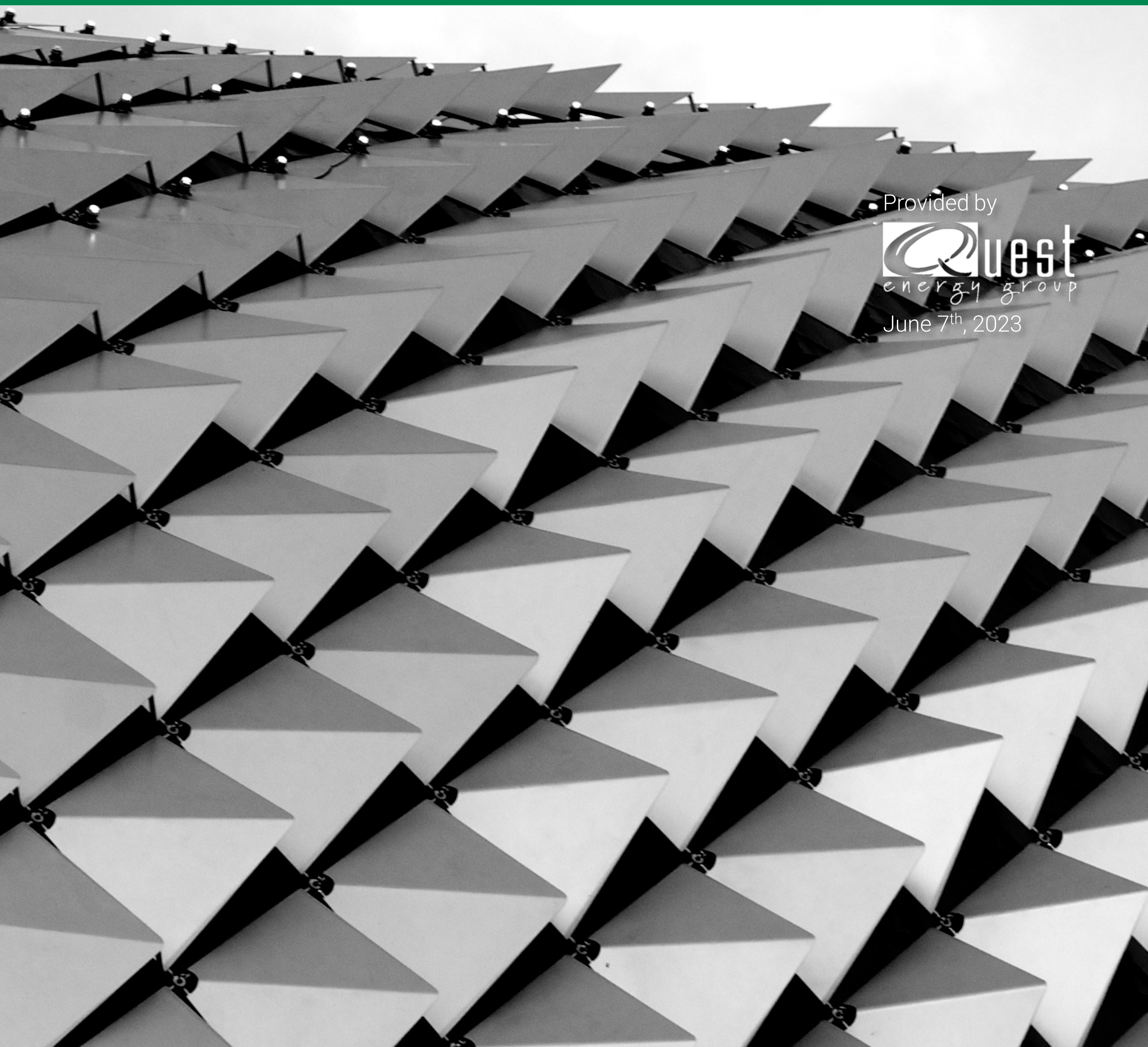
C. The Project systems are complex. To achieve the energy code and beyond, there are sophisticated mechanical and electrical systems integrated into the building. Achieving good operation of these systems is a large job, and in a remote location. To prevent major operational issues, the systems were commissioned after startup. This step provided confidence that the systems were installed and operating as specified. This process is highly recommended.

Appendix 1: Year 1 Measurement and Verification Report.

Fort Peck Wellness Center

Poplar, MT

Year 1 M&V Report



Provided by

Quest energy group

June 7th, 2023

Executive Summary

A new 2-story wellness center has been designed and constructed in Poplar, Montana. The wellness center is comprised of fitness areas, gymnasium, pool and spa, offices, and BOH support areas. The project is eligible to apply for the Energy Infrastructure Deployment on Tribal Lands Funding Opportunity 2019 (FOA Number DE-FOA-0002032). As part of the application, the project conducted a design analysis to evaluate various energy efficient designs for the envelope, lighting, HVAC, and process loads. This process was completed in 2019.

Based utility bills from March 2022 through February 2023, the Fort Peck Wellness Center annual energy output is was **524,241 kWh per year** and **48,617 therms per year,** resulting in an **EUI of 127.9 kBtu/SF/year.** Total utility cost was **$99,418 per year**, or about **$1.91 per SF/year.**

As part of the funding scope, the project is required to conduct measurement and verification for the energy efficiency improvements included in the design. The following table summarizes the electricity, gas, and cost savings for each of the energy efficiency measures compared to an IECC 2012 code compliance design. Overall, the installation of energy measures is projected to reduce annual electricity usage by about **169,664 kWh per year** and gas usage by about **24,271 therms per year**. Total annual cost savings are expected to be about **$40,177 per year**, which is a **28%** reduction in operating cost compared to an IECC 2012 baseline design.

Including the solar PV system, total annual electricity savings would be **244,152 kWh per year** and cost savings of **$45,689 per year,** resulting in a **32%** reduction in operating cost compared to IECC 2012 baseline design.

Fort Peck Wellness Center Energy Performance										
#	Run	Site Energy				Source Energy		Utility Costs		
		Electric	Gas	Total	EUI	Total	EUI	Electric	Gas	Total Cost
		(kWh)	(Therm)	MMBtu	(kBtu/ft²)	MMBtu	(kBtu/ft²)	($)	($)	($)
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	Total Savings w/ Solar PV	244,152	24,271	3,260	62.7	5,164	99.3	$ 23,845	$ 21,844	$ 45,689
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	Actual Savings w/o Solar PV	169,664	24,271	3,006	57.8	4,366	84.0			$ 40,177
	Percent Change from Preliminary Results	-4%	28%	20%	20%	12%	12%			61%

The following table summarizes the initial, estimated energy and cost savings during design phase development compared to the actual energy and cost savings for the facility. The main adjustments between the preliminary and actual energy model are as follows:

- Utility rates were updated to reflect actual rates from the Montana-Dakota Utility Co. bills. Overall, the cost of electricity and natural gas increased resulting in increased cost savings for each measure.
- Operating hours for the facility were reduced based on feedback from the facility team. As a result, total electricity savings decreased. This is especially noticeable for the improved lighting power density and dehumidification heat recovery measures.
- Initial HVAC cooling efficiencies for the design were modeled at 10.6 EER; however, the final equipment schedules show rated efficiency values of 11.1 and 12.5 EER. Additionally, the initial model did not take fan power credit or optimized fan control credit for the HVAC systems.
- Boiler efficiencies for space heating, domestic hot water, and pool heating were increased to match the mechanical and plumbing schedules, leading to increased energy savings.

Overall, utility cost savings increased from ~$25,000 to $40,000 per year and overall energy savings increased by ~20%.

#	Energy Conservation Measure	Preliminary Savings			Actual Savings		
		Electricity (kWh/year)	Natural Gas (therms/year)	Cost ($/year)	Electricity (kWh/year)	Natural Gas (therms/year)	Cost ($/year)
E1	R-31.6 Metal Exterior Wall	2,171	1,140	$841	2,317	1,352	$1,480
E2	Design Window GT	690	523	$362	928	247	$237
L1	Lighting Power Density = 0.68 W/sf	169,356	-5,981	$9,681	119,149	-998	$11,931
M1	High Efficieny DX AHUs	8,725	0	$681	55,885	3,234	$8,905
M2	High Efficiency, Condensing Boilers	-4,125	12,219	$6,888	-9,979	12,277	$10,166
P1	High Efficiency Pool Heater	0	1,286	$759	0	1,506	$1,355
P2	High Efficiency DHW Heater		Not Modeled		0	1,009	$908
P3	Dehumidification Heat Recovery for Pool Heating	560	9,764	$5,805	1,364	5,644	$5,195
	Total Savings	**177,377**	**18,951**	**$25,017**	**169,664**	**24,271**	**$40,177**
	Percent Change from Preliminary Results				**-4.3%**	**28.1%**	**60.6%**

Project Overview and Energy Model

A new 2-story wellness center has been designed for constructed in Poplar, Montana. The wellness center is comprised of fitness areas, gymnasium, pool and spa, offices, and BOH support areas. The project is eligible to apply for the Energy Infrastructure Deployment on Tribal Lands Funding Opportunity 2019 (FOA Number DE-FOA-0002032). As part of the application, the project conducted a design analysis to evaluate various energy efficient designs for the envelope, lighting, HVAC, and process loads. This process was completed in 2019.

The building has now been in operation since March of 2022. As part of the funding scope, the project is required to conduct measurement and verification for the energy efficiency improvements included in the design. Annual savings for each ECM are calculated based on International Performance Measurement and Verification Protocol (IPMVP) Option D, whole building modeling using eQUEST simulation software. Graphical representations of the baseline model are shown below.

Figure 1 – eQUEST 3D Model Schematic

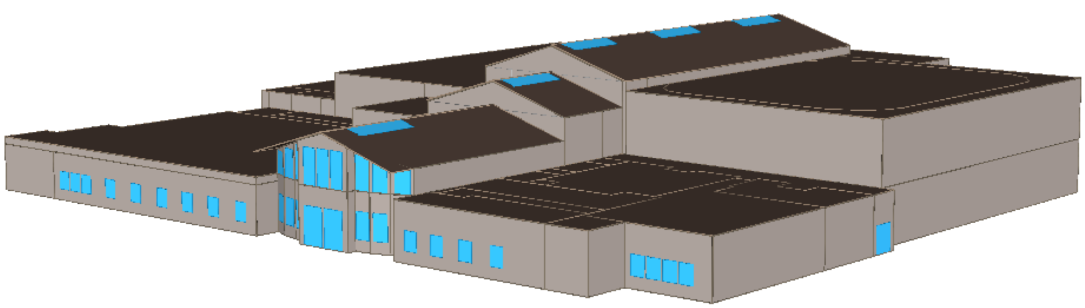
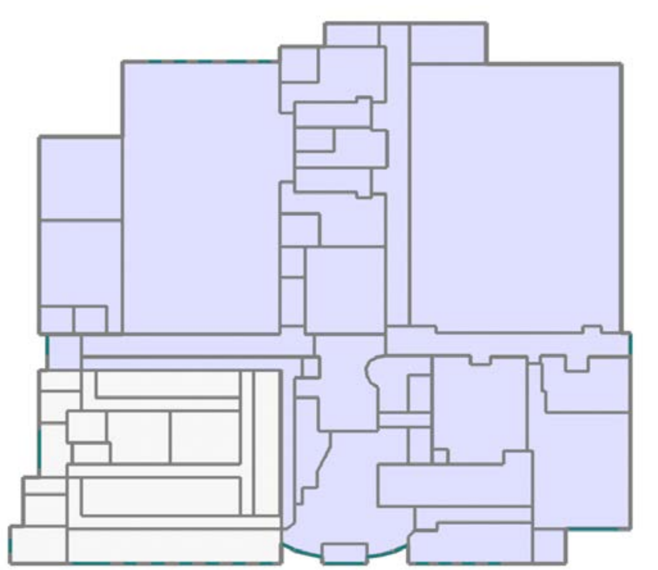


Figure 2 – eQUEST 2D Floorplan Schematic



Energy Model Calibration

The preliminary energy model developed during design phase was updated based on the following inputs and calibrated to 2022 utility data.

- Updates to operating hours and schedules for the facility
- Final envelope constructions per drawings and submittals
- Final design lighting layouts and fixtures
- Final HVAC drawings and sequence of operations
- 2022 and 2023 weather based on NOAA data (https://www.ncdc.noaa.gov/cdo-web/datatools/lcd)
- Estimated solar PV output through NREL PVWatts (https://pvwatts.nrel.gov/)

Given that the building was turned over for full operation in March of 2022, the calibration process is based on utility data from March 2022 to February 2023. Utility data from January and February 2023 was used in place of the missing January and February 2022 data, and the weather data for the model was adjusted to match this time period. The following graphs show the result of the calibration process for electricity usage. The bar chart represents the output from the energy model. The dotted black line represents electricity utility bill data, and the solid black line represents total electricity usage for the building (utility bill data + solar PV generation).

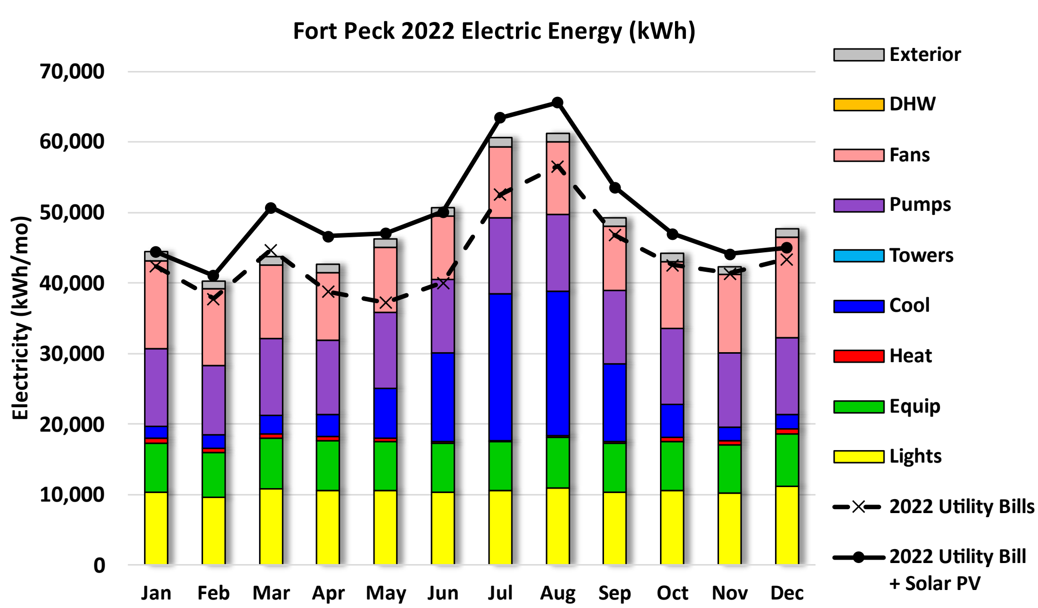


Figure 3: 2022 Electricity Calibration

The natural gas calibration is shown in the following graph. The bar chart represents the output from the energy model broken down between space heating and DHW/pool heating. The dotted black line represents natural gas utility bill data. Based on the table below, the energy model is able predict natural gas uses for most months, except for March and December. Further investigation is required to understand the anomalies in natural gas usage.

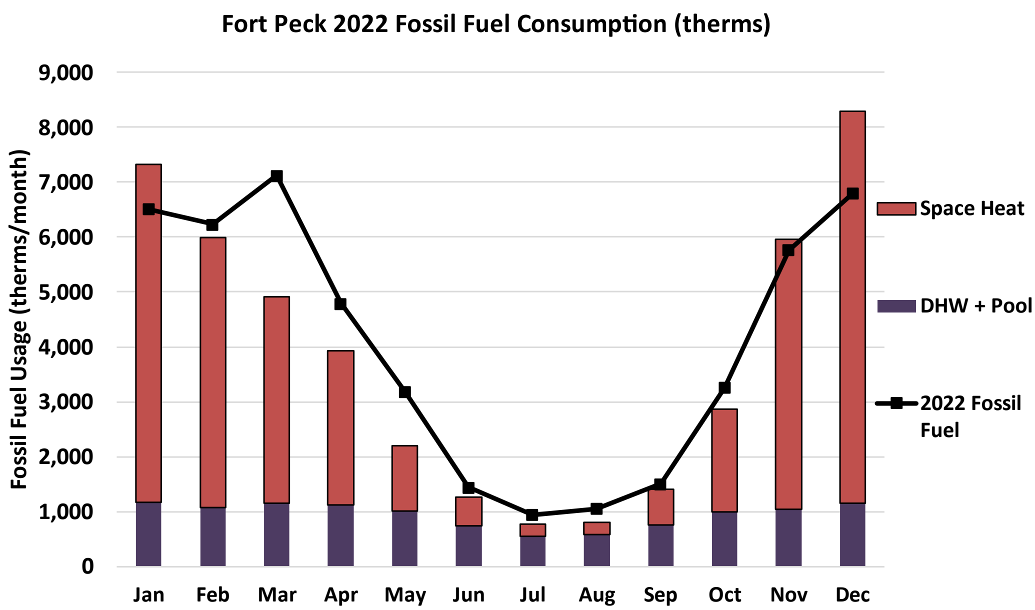


Figure 4: 2022 Natural Gas Calibration

Facility Operating Hours

The operating hours for the gym, fitness area, and walking track are 11:30AM to 7PM on Monday, Tuesday, Thursday, and Friday, and 11:30AM to 4:30 PM on Saturdays and Sundays. Swimming pool hours are from 4:30PM to 7:00 PM on Mondays, Tuesdays, and Fridays. Lap swimming is 11:30AM-12:15PM and 12:30PM to 1:15PM on Saturdays and Sundays. Open swimming is 1:30-4:15PM on Saturdays and Sundays.

The facility is closed on Wednesdays and the pool is closed on Thursdays.

The service office areas are open Monday thru Friday from 8:30AM to 4:30PM.

Utility Rates

The electric and natural gas utility rate, shown below, are based on Montana-Dakota Utilities Co. rates for Poplar, Montana.

Electric Rate
Consumption: $0.074 /kWh
Demand: $12.75/kW

Natural Gas Rate = $0.90 /therm

Pool Hot Water Load

The latent space load in the pool area is calculated based on the ASHRAE compliant pool evaporation load calculation, shown below.

Load Estimation

Loads for a natatorium include heat gains and losses from outdoor air, lighting, walls, roof, and glass. Internal latent loads are generally from people and evaporation. Evaporation loads in pools and spas are significant relative to other load elements and may vary widely depending on pool features, areas of water and wet deck, water temperature, and activity level in the pool.

Evaporation. The rate of evaporation can be estimated from empirical Equation (1). This equation is valid for pools at normal activity levels, allowing for splashing and a limited area of wetted deck. Other pool uses may have more or less evaporation (Smith et al. 1993).

$$w_p = \frac{A}{Y}(p_w - p_a)(95 + 0.425\ V) \tag{1}$$

where

w_p = evaporation of water, lb/h
A = area of pool surface, ft^2
Y = latent heat required to change water to vapor at surface water temperature, Btu/lb
p_w = saturation vapor pressure taken at surface water temperature, in. Hg
p_a = saturation pressure at room air dew point, in. Hg
V = air velocity over water surface, fpm

Table 1 Typical Natatorium Design Conditions

Type of Pool	Air Temperature, °F	Water Temperature, °F	Relative Humidity, %
Recreational	75 to 85	75 to 85	50 to 60
Therapeutic	80 to 85	85 to 95	50 to 60
Competition	78 to 85	76 to 82	50 to 60
Diving	80 to 85	80 to 90	50 to 60
Elderly swimmers	84 to 90	85 to 90	50 to 60
Hotel	82 to 85	82 to 86	50 to 60
Whirlpool/spa	80 to 85	97 to 104	50 to 60

Based on this calculation, the hourly latent load in the pool area was determined to be 128,062 Btu/hr during occupied hours and 76,249 Btu/hr during unoccupied hours. It was also estimated that the pool hot water load would be equivalent. Thus, the pool hot water load is given a constant hourly schedule of 128,062 Btu/hr during occupied hours and 76,249 Btu/hr during unoccupied hours.

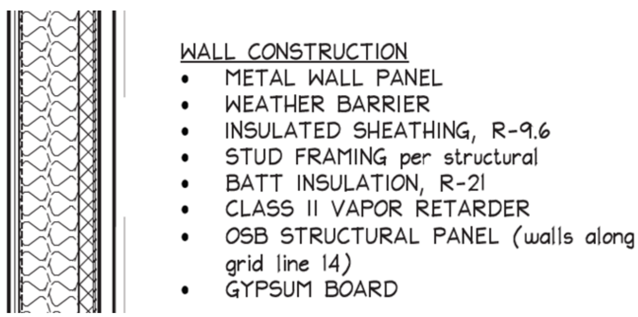
Energy Efficiency Measures

The following sections outline the different energy efficiency measures evaluated in the energy model analysis.

ECM E1: Wall Assembly – R-31.6 Metal Wall Panel Façade

The building envelope characteristics for the Fort Peck Wellness Center are based on IECC 2012 code compliant insulation and assembly values for Climate Zone 6. Thus, the baseline exterior wall construction is steel-framed, R-13 Batt + R-7.5 ci. The total U-value for the baseline condition is U = 0.064 (Btu/h-ft^2-F).

The design exterior wall conditions is R-31.6 metal wall panel exterior wall. A detailed layer construction for wall is given in the following image. The total assembly insulation U-value including the effects of R-21 insulation between 10" metal frames is U = 0.049 (Btu/h-ft^2-F).



Compared to an IECC complaint baseline exterior wall, the R-31.6 Metal Wall Panel would result in electricity and natural gas savings of about 2,317 kWh per year and 1,352 therms per year, respectively. Total cost savings would be about $1,480 per year.

ECM E2: Design Window Glass

The IECC 2012 baseline window values are U = 0.064 (Btu/h-ft^2-F) and a SHGC of 0.25.

The project design utilizes a variety of different glass types as described below. Each glass type is described below.

GL-1 – Windows A

Window Efficiency

Model	GlassPack	GlassThickness	Description	UFactor	SHGC	VT	CR	ER
A682	Climatech-TG2 ThermD	Double Strength	1 3/8" TIG, DS LOE2, Dbl Argon, ThermD	0.18	0.23	0.38	75	30
A682	Climatech-TG2 ThermD	Triple Strength	1 3/8" TIG, TS LOE2, Dbl Argon, ThermD	0.19	0.22	0.37	71	28

Hollow Metal Glazing for Windows B + C

6mm SunGuard® SuperNeutral 68 on Clear(2) (SGSN68C6.grd) (Guardian) \| Air (10%) / Argon (90%) Mix 1/2" (12.7mm) \| Clear 6mm (Vitro Architectural Glass) \| Air 1/2" (12.7mm) \| ClimaGuard IS-20, Interior Surface LE on 6mm Clr(6) (CGIS-20c6.0.grd) (Guardian)

Thickness (inches)	Transmittance UV %	Transmittance Visible %	Transmittance Total Solar %	Exterior Solar Reflectance %	Exterior Visible Reflectance %	Interior Visible Reflectance %	U-Value (Winter Nighttime) (Btu/hr*ft2*°F)	U-Value(Summer Daytime) (Btu/hr*ft2*°F)	Shading Coefficient (SC)	Solar Heat Gain Coefficient (SHGC)	Light To Solar Gain (LSG)	Thermal Stress Risk
1 11/16 "	23	59	27	34	15	19	0.16	0.15	0.38	0.33	1.79	Med

GL-3 Windows E

	Single-Hung	
	U-Factor	*SHGC*
Clear Insulated	0.48	0.63

GL-4 – Storefront Windows

6mm SunGuard® SuperNeutral 68 on Clear(2) (SGSN68C6.grd) (Guardian) \| Air (10%) / Argon (90%) Mix 1/2" (12.7mm) \| SunGuard® IS 20 Interior Surface LE on 6mm clear(4) (SGIS20C6.grd) (Guardian)

Thickness (inches)	Transmittance UV %	Transmittance Visible %	Transmittance Total Solar %	Exterior Solar Reflectance %	Exterior Visible Reflectance %	Interior Visible Reflectance %	U-Value (Winter Nighttime) (Btu/hr*ft2*°F)	U-Value(Summer Daytime) (Btu/hr*ft2*°F)	Shading Coefficient (SC)	Solar Heat Gain Coefficient (SHGC)	Light To Solar Gain (LSG)	Thermal Stress Risk
1 "	28	66	32	32	11	13	0.20	0.18	0.42	0.36	1.83	Med

Compared to an IECC complaint baseline glass, the design glass results in electricity and natural gas savings of about 928 kWh per year and 247 therms per year, respectively. Total cost savings would be about $237 per year.

ECM L1: High Performance Lighting Design

The baseline lighting design LPD for the Fort Peck Wellness Center is 1.05 W/sf with occupancy sensors in locker rooms, offices, restrooms, storage, and lounge areas. Based on the final lighting design, the wellness center has an overall LPD of 0.68 W/sf through the use of high efficiency LED fixtures, strategic lighting layouts, and fully automated lighting controls. A summary of the space types with baseline and design lighting values are shown in the following table.

Space Type	Floor Area (ft^2)	Baseline LPD (W/ft^2)	Proposed LPD (W/ft^2)
Gym (Playing Area)	9,771	1.40	0.66
Conference/Meeting	7,636	1.08	1.01
Corridor	5,495	0.70	0.54
Classroom	3,861	1.17	0.40
Gym (Exercise Area)	3,708	0.90	0.45
Office (Enclosed)	3,529	0.99	0.71
Mechanical	3,351	1.10	0.49
Lobby	2,582	1.10	1.09
Locker Room	2,297	0.72	0.95
Restrooms	1,646	0.90	0.71
Classroom (Primary/Secondary	1,007	1.17	0.49
Food Preparation	991	1.20	0.77
Lounge/Recreation	886	0.72	0.35
Hospital-Exam/Treatment	870	1.70	0.98
Storage Active	813	0.72	0.37
Stairs	776	0.70	0.42
Hospital-Nurses' Station	468	1.00	0.66
Electrical	304	1.10	0.54
Break Room	231	0.72	0.59
Hospital-Medical Supply	180	1.40	0.67
Total	50,402	1.06	0.68

The proposed lighting design would result in electricity savings of about **119,149 kWh per year** and an increase in natural gas of about **994 therms per year**. Total cost savings would be about **$11,931 per year**.

M1: High Efficient DX AHUs

The baseline system is determined by IECC 2012 Section 407 Table C407.5 and C407.5.1. The main HVAC system type for the Fort Peck Wellness Center is a packaged VAV system with hot water reheat. This system serves the office spaces, fitness areas, classrooms, locker rooms, and gymnasium. The PVAV system is auto sized at 1.0 cfm/sf with fan power sized to 1.20 W/cfm. Ventilation rates are modeled identical to the proposed case at about 0.24 cfm/sf. The cooling efficiency for the packaged system is 9.8 EER. The system utilizes a fully functioning economizer with a maximum shut-off temperature of 70 °F. Discharge air temperature for the PVAV system is maintained at 55 °F during peak load conditions and resets up to 60 °F during part load conditions. The PVAV units operates continuously during operating hours and cycles to maintain the 68F/75F setpoints in the space. A summary of the baseline HVAC systems are shown below.

Baseline HVAC Summary Table

System Name	eQUEST System Type	Total Area Served (sq. ft.)	Supply Flow (cfm)	Supply Flow (cfm/sf)	Outside Air Flow (cfm)	Supply Fan (kW)	Total Fan Power (W/cfm)	Cooling Capacity (kBtu/hr)	Heating Capacity (kBtu/hr)	Cooling Efficiency	Heating Efficiency (%)
AHU-1 Gymnasium	PVAV	15,367	17,086	1.11	5,655	21.9	1.284	693	554	EER 9.8	HW
AHU-3	PVAV	15,125	10,067	0.67	3,201	13.1	1.304	366	326	EER 9.8	HW
AHU-2	PVAV	12,399	14,145	1.14	1,839	18.2	1.284	436	458	EER 9.8	HW
Dehumidification Unit	Pool PSZ	6,271	8,625	1.38	1,553	8.3	0.964	240	416	EER 10.8	HW
Unit Heater	Unit Heaters	2,279	1,916	0.84	-	0.6	0.300	-	70	N/A	HW
Total		51,441	51,839	1.01	12,248	62.1	1.198	1,494	1,754		

The design HVAC systems utilize cooling efficiencies of EER 11.1 to EER 12.5 with airflow size to 0.94 CFM/SF. Total fan power is slightly greater than the baseline system at 1.31 W/CFM. The cooling efficiency for the packaged system is 9.8 EER. The system utilizes a fully functioning economizer with a maximum shut-off temperature of 70 °F. Discharge air temperature for the PVAV system is maintained at 55 °F during peak load conditions and resets up to 70 °F during part load conditions. A summary of the design HVAC system is shown below.

Proposed HVAC Summary Table

System Name	System Description	Total Area Served (sq. ft.)	Supply Flow (cfm)	Supply Flow (cfm/sf)	Outside Air Flow (cfm)	Supply Fan (kW)	Total Fan Power (W/cfm)	Cooling Capacity (kBtu/hr)	Heating Capacity (kBtu/hr)	Cooling Efficiency (COP)	Heating Efficiency
AHU-1 Gymnasium	PVAV	15,367	13,000	0.85	5,655	22.4	1.726	400	421	EER 12.5	HW
AHU-3	PVAV	15,125	12,100	0.80	3,194	14.6	1.204	283	392	EER 11.1	HW
AHU-2	PVAV	12,399	14,000	1.13	1,848	20.8	1.487	333	454	EER 11.1	HW
Dehumidification Unit	Pool PSZ	6,271	7,500	1.20	1,553	5.2	0.694	226	335	EER 11.1	HW
Unit Heater	Unit Heaters	2,279	1,732	0.76	-	0.2	0.100	-	65	N/A	HW
Total		51,441	48,332	0.94	12,250	63	1.308	1,241	1,602	-	-

Upgrading to the high efficiency DX units with an efficiency of EER 11.1 to EER 12.5 results in electricity savings of about **55,885 kWh per year,** natural gas savings of **3,234 therms per year**, and cost savings would be about **$8,905 per year.**

M2: High Efficient, Condensing Hot Water Boiler

The IECC baseline hot water boiler efficiency is 80%. The design hot water boiler is a Lochinvar condensing boiler with a rate efficiency of 90% at 120F entering HW conditions.

CONDENSING BOILER SCHEDULE (35% PROP. GLYCOL)

PLAN CODE	MFGR	MODEL NUMBER	BOILER TURNDOWN	MBH INPUT	MAX MBH OUTPUT	DESIGN GPM	BOILER MIN FLOW	EWT/LWT	W.P.D.	FLUE SIZE	C.A. SIZE	POWER	REMARKS
B-1/B-2	LOCHINVAR	CREST FBN-2501	20:1	2500	2240	170	25 GPM	120/150	4'	9"Ø CATEGORY IV AL294C	8"Ø GALV. STEEL	208V/3 5.6 MCA	3600 OPERATING WEIGHT

Upgrading to a condensing boiler results in natural gas savings of about **12,277 therms per year** and an increase in electricity of about **9,979 kWh per year**. Total cost savings are expected to be about **$10,166 per year**.

P1: High Efficiency, Condensing Hot Water Boiler for Pool Heating

The IECC baseline hot water boiler efficiency is 80%. The design hot water boiler is a Lochinvar condensing boiler with a rate efficiency of 98% at 80F entering HW conditions. This is assumed based on the specification for the DHW boiler. See DHW boiler spec below.

Upgrading to a condensing boiler with a 98% efficiency at 80F entering water results in gas savings of about **1,506 therms per year** and total cost savings of **$1,355 per year**.

P2: High Efficiency, Condensing Hot Water for DHW Heating

The IECC baseline hot water boiler efficiency is 80%. The design hot water boiler is a Lochinvar condensing boiler with a rate efficiency of 98% at 80F entering HW conditions.

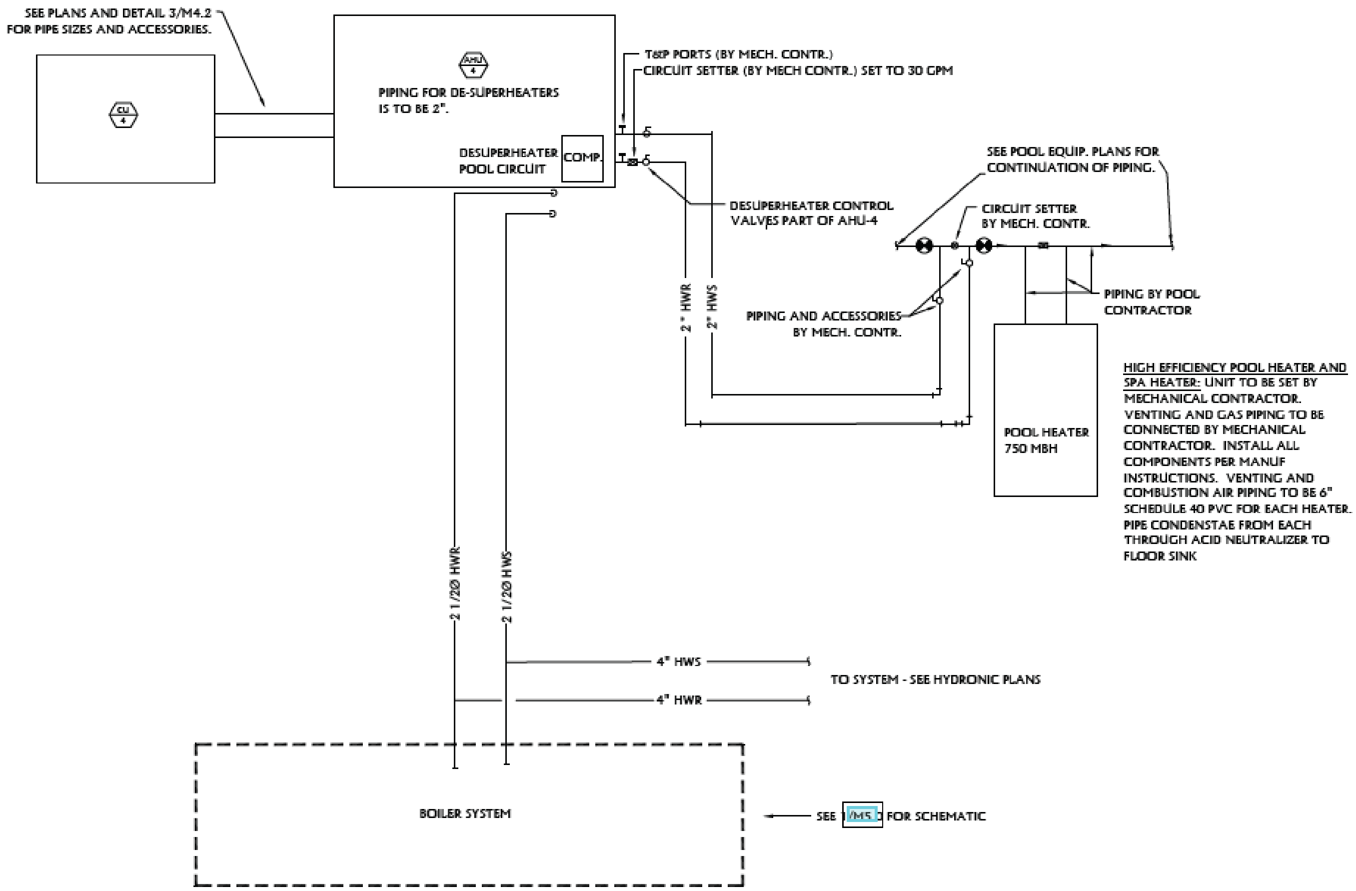
DOMESTIC HOT WATER HEATER SCHEDULE (ELEV 1,990 FT)

PLAN CODE	MFGR	MODEL NUMBER	MBH INPUT @ SEA LVL	MBH OUTPUT @ SEA LVL	THERM EFF	FUEL	RECOVERY @ 100 F TEMP RISE	GAL CAP.	VENT & C/A SIZE	ELEC.	PHYSICAL SIZE	SHIP WEIGHT LBS.	REMARKS
DWH-1	LOCHINVAR	AWN501PM	500	490	98%	N.G.	582 GPH	--	4"	120V/60A/1PH	15 1/2" X 31 1/2" X 42 1/2"	339	PROVIDE BACNET CONNECTION FOR DDC MONITORING

Upgrading to a condensing boiler with a 98% efficiency at 80F entering water results in gas savings of **1,009 per year** and total cost savings of **$908 per year**.

P3: Dehumidification Heat Recovery for Pool Heating

Based on the diagram below, the project is expected to recover waste heat from the pool HVAC system for space heating and pool hot water heating. It is assumed that 75% of the recovered heat from the dehumidification process can be used. With this assumption, the electricity savings are about **1,364 kWh per year** and gas savings are about **5,644 therms per year**. Total cost savings are **$5,195 per year**.



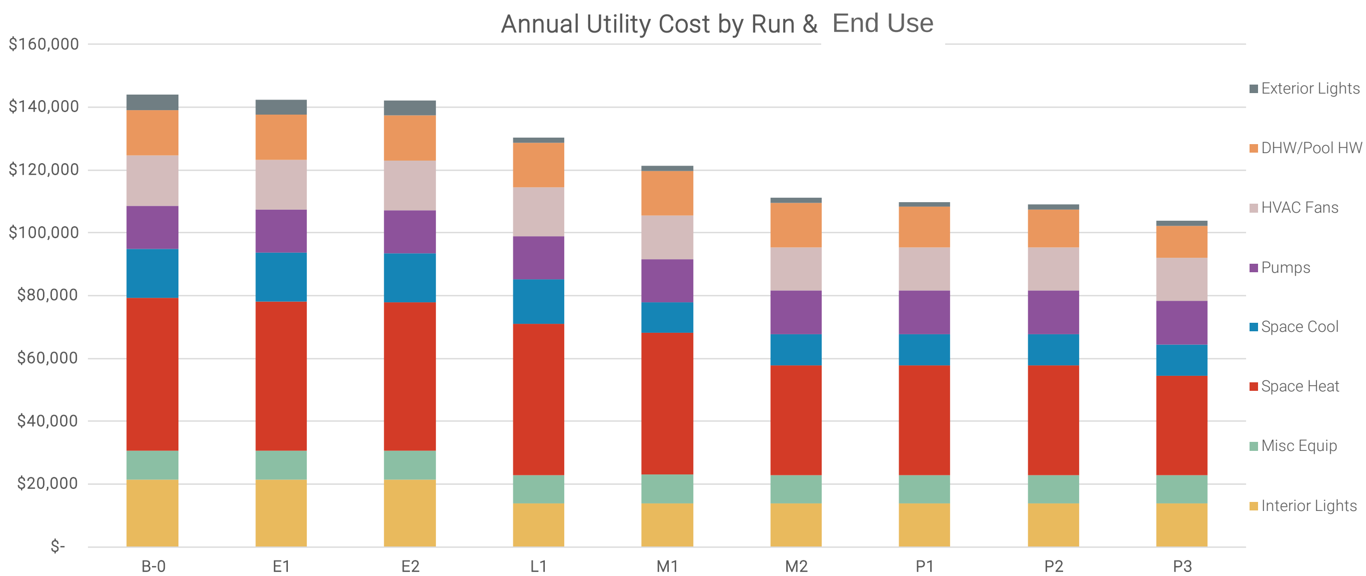
Energy Analysis Results

The following table summarizes the electricity, gas, and cost savings for each of the energy efficiency measures input into the project design. Overall, the installation of energy measures for the project is projected to reduce electricity usage by about **169,664 kWh per year** and gas usage by about **24,271 therms per year**. Total cost savings is expected to be about **$40,177 per year**, which would be a **28%** reduction in operating cost compared to an IECC 2012 baseline design.

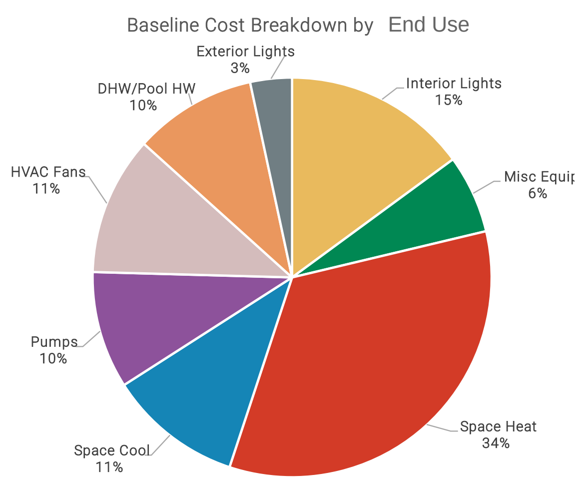
Including the solar PV system, total electricity savings would be **244,152 kWh per year** and cost savings of **$45,689 per year,** resulting in a **32%** reduction in operating cost compared to IECC 2012 baseline design.

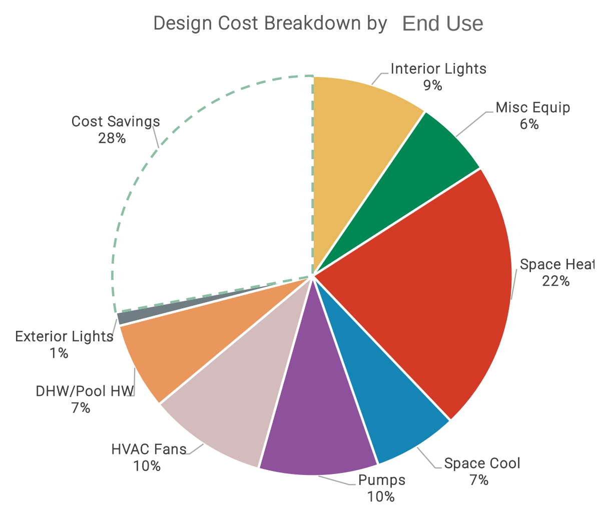
Fort Peck Wellness Center Energy Performance										
		Site Energy				Source Energy		Utility Costs		
#	Run	Electric (kWh)	Gas (Therm)	Total MMBtu	EUI (kBtu/ft²)	Total MMBtu	EUI (kBtu/ft²)	Electric ($)	Gas ($)	Total Cost ($)
B-0	IECC 2012 Baseline	743,057	69,970	9,532	183.3	15,308	294.4	$ 80,955	$ 62,973	$ 143,928
E1	R-31.6 Metal Exterior Wall	740,740	68,618	9,389	180.6	15,141	291.2	$ 80,692	$ 61,756	$ 142,448
E2	Design Window GT	739,812	68,371	9,361	180.0	15,105	290.5	$ 80,677	$ 61,534	$ 142,211
L1	Lighting Power Density = 0.68 W/sf	620,663	69,369	9,055	174.1	13,933	267.9	$ 67,848	$ 62,432	$ 130,280
M1	High Efficieny DX AHUs	564,778	66,135	8,541	164.2	12,995	249.9	$ 61,853	$ 59,522	$ 121,375
M2	High Efficiency, Condensing Boilers	574,757	53,858	7,347	141.3	11,813	227.2	$ 62,737	$ 48,472	$ 111,209
P1	High Efficiency Pool Heater	574,757	52,352	7,196	138.4	11,655	224.1	$ 62,737	$ 47,117	$ 109,854
P2	High Efficiency DHW Heater	574,757	51,343	7,095	136.4	11,549	222.1	$ 62,737	$ 46,209	$ 108,946
P3	Dehumidification Heat Recovery for Pool Heating	573,393	45,699	6,526	125.5	10,942	210.4	$ 62,622	$ 41,129	$ 103,751
R1	Solar PV System Generation	498,905	45,699	6,272	120.6	10,144	195.1	$ 57,110	$ 41,129	$ 98,239
Incremental Savings relative to Previous Measure										
E1	R-31.6 Metal Exterior Wall	2,317	1,352	143	2.8	167	3.2	$ 263	$ 1,217	$ 1,480
E2	Design Window GT	928	247	28	0.5	36	0.7	$ 15	$ 222	$ 237
L1	Lighting Power Density = 0.68 W/sf	119,149	(998)	307	5.9	1,172	22.5	$ 12,829	$ (898)	$ 11,931
M1	High Efficieny DX AHUs	55,885	3,234	514	9.9	938	18.0	$ 5,995	$ 2,910	$ 8,905
M2	High Efficiency, Condensing Boilers	(9,979)	12,277	1,194	23.0	1,182	22.7	$ (884)	$ 11,050	$ 10,166
P1	High Efficiency Pool Heater	-	1,506	151	2.9	158	3.0	$ -	$ 1,355	$ 1,355
P2	High Efficiency DHW Heater	-	1,009	101	1.9	106	2.0	$ -	$ 908	$ 908
P3	Dehumidification Heat Recovery for Pool Heating	1,364	5,644	569	10.9	607	11.7	$ 115	$ 5,080	$ 5,195
R1	Solar PV System Generation	74,488	-	254	4.9	798	15.3	$ 5,512	$ -	$ 5,512
Total Savings relative to Baseline										
	Total Savings w/o Solar PV	**169,664**	**24,271**	**3,006**	**57.8**	**4,366**	**84.0**	**$ 18,333**	**$ 21,844**	**$ 40,177**
	Total Percent Savings w/o Solar PV	**23%**	**35%**	**32%**	**32%**	**29%**	**29%**	**23%**	**35%**	**28%**
	Total Savings w/ Solar PV	**244,152**	**24,271**	**3,260**	**62.7**	**5,164**	**99.3**	**$ 23,845**	**$ 21,844**	**$ 45,689**
	Total Percent Savings w/ Solar PV	**33%**	**35%**	**35%**	**35%**	**34%**	**34%**	**30%**	**35%**	**32%**
Savings Comparison to Preliminary Analysis										
	Preliminary Savings w/o Solar PV	**177,377**	**18,951**	**2,500**	**48.1**	**3,890**	**74.8**			**$ 25,017**
	Actual Savings w/o Solar PV	**169,664**	**24,271**	**3,006**	**57.8**	**4,366**	**84.0**			**$ 40,177**
	Percent Change from Preliminary Results	**-4%**	**28%**	**20%**	**20%**	**12%**	**12%**			**61%**

The following graph shows annual utility costs by end-use for each energy measure.

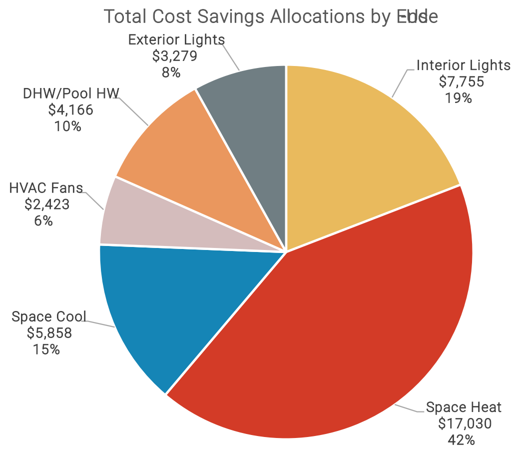


The following pie charts show the cost breakdown by end-use between the baseline (IECC 2012 model) and the calibrated design energy model.





The following pie charts show the total cost savings broken down and allocated to each end-use. Based on this pie chart, 42% of the total cost savings are from reductions in space heating energy usage. This is to be expected as space heating comprises 33% of the total energy cost for the facility.



The following table summarizes the initial, estimated energy and cost savings during design phase development compared to the actual energy and cost savings for the facility. The main adjustments between the preliminary and actual energy model are as follows:

- Utility rates were updated to reflect actual rates from the Montana-Dakota Utility Co. bills. Overall, the cost of electricity and natural gas increased resulting in increased cost savings for each measure.
- Operating hours for the facility were reduced based on feedback from the facility team. As a result, total electricity savings decreased. This is especially noticeable for the improved lighting power density and dehumidification heat recovery measures.
- Initial HVAC cooling efficiencies for the design were modeled at 10.6 EER; however, the final equipment schedules show rated efficiency values of 11.1 and 12.5 EER. Additionally, the initial model did not take fan power credit or optimized control credit for the HVAC systems.
- Boiler efficiencies for space heating, domestic hot water, and pool heating were increased to match the mechanical and plumbing schedules, leading to increased energy savings.

Overall, utility cost savings increased from **~$25,000 to $40,000** per year and overall energy savings increased by **~20%**.

#	Energy Conservation Measure	Preliminary Savings			Actual Savings		
		Electricity (kWh/year)	Natural Gas (therms/year)	Cost ($/year)	Electricity (kWh/year)	Natural Gas (therms/year)	Cost ($/year)
E1	R-31.6 Metal Exterior Wall	2,171	1,140	$841	2,317	1,352	$1,480
E2	Design Window GT	690	523	$362	928	247	$237
L1	Lighting Power Density = 0.68 W/sf	169,356	-5,981	$9,681	119,149	-998	$11,931
M1	High Efficieny DX AHUs	8,725	0	$681	55,885	3,234	$8,905
M2	High Efficiency, Condensing Boilers	-4,125	12,219	$6,888	-9,979	12,277	$10,166
P1	High Efficiency Pool Heater	0	1,286	$759	0	1,506	$1,355
P2	High Efficiency DHW Heater		Not Modeled		0	1,009	$908
P3	Dehumidification Heat Recovery for Pool Heating	560	9,764	$5,805	1,364	5,644	$5,195
	Total Savings	177,377	18,951	$25,017	169,664	24,271	$40,177
	Percent Change from Preliminary Results				**-4.3%**	**28.1%**	**60.6%**