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Michigan Fishery Energy Audits

BE 456 HONORS OPTION

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Justification

Rising energy costs are a major concern in today's society, especially for Michigan which is a major importer of energy. Michigan was tied for last a couple of years, with a high of 46th in USDA energy efficient state rankings up until 2009. This poor performance of Michigan's food and agricultural sector denoted a problem for energy consumers statewide. However, after the establishment of the Michigan Farm Energy Program, the state's ranking jumped up to 5th place in 2012. This had many potential impacts on cost, operational scheduling, equipment and processes, and the production and welfare of crops, animals, and fish. In addition to cost, energy efficiency is a major issue. "By displacing traditional fossil fuel energy, the energy efficiency program alone could save Michigan $3 billion in electricity costs over the next 20 years. These results compare favorably to other statewide energy efficiency programs." This quote reflects the consensus that energy efficiency projects are gaining popularity/funding, especially in Michigan.

Energy Audit Background

A tool that can be used to combat rising energy costs and usage is an energy audit. The definition of an energy audit is an assessment of the energy needs and efficiency of a buildings, equipment or operational processes. The ultimate goal of an energy audit is to save energy or increase productivity by implementing Energy Conservation Measures (ECM). These ECM's are in compliance with various standards, which are different for the various types of energy audits available. For example, farm and food processing energy audits us Type 1 and Type 2 ANSI/ASABE S612 standards, while home and residential energy audits use BPI and RESNET standards. This ensures that the energy audit can be conducted with quality.

There are also specific expectations of an energy audit. For example, a "whole enterprise" approach is considered when developing ECM's or operational adjustments, as it is generally preferred by management. The energy audit must also be conducted "with eyes on-site" by the certified auditor. Remote auditing via surveys, questionnaires, or third-party representatives is not adequate for an energy audit. The energy audit program at MSU aims for type 2 level standards based on the ASABE and ANSI S612 standards for energy audits. Finally, auditor and farmer feedback is considered, as well as funding options at the federal, state, and utility level.

The goal of an energy audit is simple: to reduce energy cost and improve energy efficiency. This involves a baseline inventory of energy use at the facility. Implementation projects are then prioritized based on energy efficiency, payback period, return on investment, capital outlay, implementation duration, and complexity. These projects improve general operational efficiency. Additionally, on-site energy use and source options are evaluated, and additional funding and support options are investigated.

In order to initiate an energy audit, multiple documents and additional information is required. This includes monthly utility and fuel bills for up to three years prior to the audit, as well as the monthly production and output for one full year. Additionally, the age, operational duration, and technical information regarding equipment and motors needs to be provided. All of this information in addition to the facility's management strategies, preferences, and plans can be used to initiate the energy audit process.

Fish Hatcheries Background

There are currently six main fish hatcheries in Michigan, each dedicated to preserving the wild fish populations of inland waters and the Great Lakes. All of the fish hatcheries have informational centers designed to educate the public on the local ecosystems and impacts on the wild fish populations. Fishing is the third largest industry for tourism in Michigan, which means that all of these fish hatcheries are important as a source of tourism in Michigan, as the stock populations need to be maintained for fishing. Three of the six main hatcheries in Michigan include Harrietta State Fish Hatchery, Platte River Fish Hatchery, and Wolf Lake State Hatchery (Figure 1).

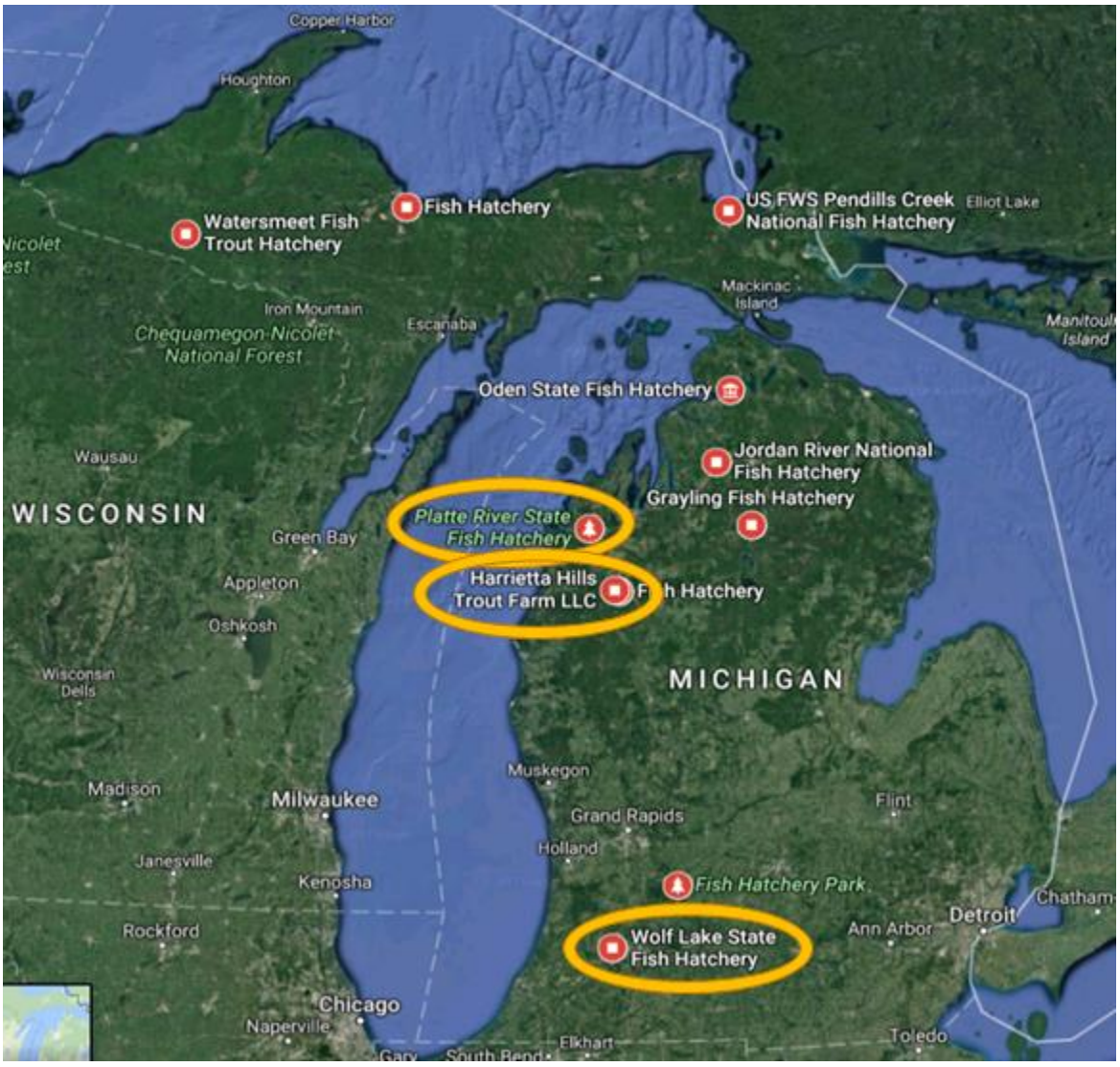

Figure 1. *Fish hatcheries located in Michigan*

Harrietta State Fish Hatchery was first opened in 1901 and is located near Harrietta, Michigan. They mainly rear rainbow trout for Michigan's inland waters, and brown trout for the Great Lakes. Their facilities were completely renovated in 1979, and they currently have indoor

and outdoor rearing facilities. Platte River Fish Hatchery is located in Beulah, Michigan, and it was converted to the state's main salmon hatchery in 1972. They rear both Coho and Chinook salmon, and they have recently been outfitted with a new effluent treatment system, liquid oxygen aeration structures, and water flow monitoring equipment. Finally, Wolf Lake State Fish Hatchery rears four different species of fish, and it is located in Mattawan, Michigan. Their facilities were renovated in 1983, and they are capable of rearing both cold water and cool water fish in their indoor and outdoor facilities.

Financial Findings

After conducting a full energy audit at all three of the facilities, the team at MSU was able to report various financial evidence and findings. At the Wolf Lake facility, three compressors and four adsorption oxygen generators were eliminated, and a liquid oxygen bulk tank was installed in 2000, which saves about $20,000 per year. Also in 2000, insulation was added to the roof of the hatchery building. Variable frequency drives (VFD) were added to Well #4 and Well #7 in 2004, which saves about $40 per day when they are running. Based on well pumping records from 2015, the two wells operated 212 days annually, which yields a savings of approximately $8,500 per year. Insulation was added on steam piping in 2014, which resulted in a payback period less than one year according to the Department of Energy's information. Additionally, 54 tank room lighting fixtures were converted from 70 watt sodium bulbs to 18 watt LED bulbs. In 2015, Well #6 motor was replaced with a higher efficiency motor. Based on flow data from 2015, the energy usage was determined to estimate an on-line price for the motor. In addition to the sodium bulbs, T12 fluorescent tubes were replaced with more energy efficient T8 fluorescent tubes. This saves about 10% of the electricity usage when combined with the replacement of magnetic ballasts with electronic ballasts. The T8 tubes had green ends, which signified that they contained less mercury. Other T8 fluorescent tubes were also replaced with quality LED tubes. A comprehensive summary of the payback periods for Wolf Lake State Fish Hatchery can be found in Table 1.

Table 1. *Financial findings for the energy audit at Wolf Lake State Fish Hatchery*

System	Energy Savings (MMBtu/Year)			Savings ($/Year)	Cost to Implement	Payback (Years)
	Total	Savings	Savings %			
Visitor Ctr. - Ex. Furnaces	480.0					
Energy Star Furnaces	384.0	96.0	20.0%	$559	$4,500	8.0
Hatchery Ex. Lighting	55.7					
Hatchery Prop. Lighting	20.8	34.9	62.7%	$1,023	$2,802	2.7
Lab & Shop Ex. Lighting	8.2					
Lab & Shop Prop. Lighting	3.5	4.7	57.1%	$137	$472	3.5
Visitor Ctr. Ex. Lighting	48.8					
Visitor Ctr. Prop. Lighting	6.1	42.7	87.6%	$1,253	$1,496	1.2
Hatchery - No Sensors	43.7					
Hatchery - Sensors	26.2	17.5	40.0%	$512	$1,050	2.0
Lab & Shop - No Sensors	3.8					
Lab & Shop - Sensors	2.3	1.5	40.0%	$44	$250	5.6
Visitor Ctr. - No Sensors	5.7					
Visitor Ctr. - Sensors	3.4	2.3	40.0%	$67	$650	9.7
Existing Well Motors	1,949.4					
High Efficiency Motors	1,677.3	272.1	14.0%	$7,976	$16,100	2.0
High Efficiency - No VFD	649.1					
High Efficiency - VFD	559.0	90.1	13.9%	$2,640	$6,400	2.4
Existing Refrigerators	21.4					
Energy Star Refrigerators	5.2	16.2	75.8%	$476	$2,000	4.2
Totals		578.0	17.7%	$14,687	$35,720	2.4

Various financial evidence and findings were also reported for the Platte River Fish Hatchery. In 2011, insulation was installed in the windows of the pump house, and heated baseboards were installed in the manifold room below the pump house for a combined cost of $500. The average cost to heat the building during the prior two years was $4,678 each year, and since then the average cost has been $1,299 per year; this results in an approximate savings of $,3379 per year. That equates to a reduction in heating costs over 72 percent. The $500 investment in 2011 has led to an approximate savings of $13,516 over the four years leading up to 2015. In 2012, the Cherryland Electric's capital credits program was used to fund the installation of two variable frequency drives (VFD's) on the two Brundage Creek Pumps. Also, two pumps and motors were removed from the service water system, and VFD's and control center were added to the three service water wells.

The lighting was also upgraded throughout the facility from T12 to T8 ballasts and bulbs in 2012. The total electrical usage during the two years prior averaged 1.39 million KWH. In the two years since those changes, the overall usage has averaged to about 1.30 million KWH. Using the average unit cost of $.08 a KWH in 2012, $7,188 has been saved per year during the following two years. Additionally, a new high efficiency burner was installed, and controls were implemented on a production water boiler. However, the savings were difficult to track due to the highly variable nature of winter severity since installation. Table 2 depicts the various payback periods associated with the energy audit for the Platte River Fish Hatchery.

Table 2. *Financial findings for the energy audit at Platte River Fish Hatchery*

Electricity ECM	Energy Savings (kWh/yr)	Energy Savings (MMBtu/yr)	Annual Cost Savings	Cost to Replace	Payback (years)
Lighting	34,517	117.8	$2,830	$5,000	1.8
Occupancy Lighting	6,949	23.7	$570	$850	1.5
Spring Pump VFD	133,061	454.0	$10,911	$21,000	1.9
Electric Motor Upgrade	174,047	593.8	$14,272	$32,500	2.3
Refrigerator Replacement	598	2.0	$92	$450	4.9
TOTAL	**349,172**	**1,191.4**	**$28,675**	**$59,800**	**2.1**

Natural Gas ECM	Energy Savings (Ccf/yr)	Energy Savings (MMBtu/yr)	Annual Cost Savings	Cost to Replace	Payback (years)
Unit Heater Upgrade	2,643	272.2	$1,295	$4,400	3.4
Heat Exchanger	22,036	2,269.7	$10,798	$22,000	2.0
Boiler Economizer	10,204	1,051.0	$5,000	$15,000	3.0
Strip Curtains	2,020	208.1	$495	$1,000	2.0
Service Bldg Boiler Replacement	3,316	341.5	$1,318	$5,000	3.8
Hot Water Pipe Insulation	2	0.2	$4	$10	2.5
Water Heater Blanket	5	0.5	$7	$30	4.3
Total	**40,226**	**4,143.2**	**$18,917**	**$47,440**	**2.5**
TOTAL Savings		**5,321.4**	**$47,274**	**$107,540**	**2.3**

Energy Source	Energy Usage	Energy Usage (MMBtu/yr)	Energy Savings (MMBtu/yr)	Percent Energy Savings/yr	Saving ($/yr)
Electrical (kWh/yr)	1,433,300	4,890.4	1,191.4	24.4%	$28,675
Natural Gas (Ccf/yr)	245,559	25,292.6	4,143.2	16.4%	$18,917
Total		**30,183.0**	**5,334.6**	**17.7%**	**$47,592**

The team at MSU reported financial evidence and findings for the third hatchery, Harrietta State Fish Hatchery. Two 100hp and one 40hp production well motors were replaced with high efficiency motors at a cost of approximately $27,000 in 2010. The data from the three years prior to replacement reported average usage of 1.74 million KWH per year. Three years after replacement, the average usage dropped to 1.48 million KWH per year; replacing the motors saved an average of 256,543 KWH per year. Using the average unit cost of $0.095 per KWH in 2010, $24,371 per year was estimated to be saved, which resulted in a payback period of just over a year. In 2012, the facility's lighting was upgraded from T12 bulbs and ballasts to more efficient T8 bulbs and ballasts at a cost of $1,602. This resulted in an estimated annual savings of $120 per year, which equated to a 13 year payback period. The 125hp motor on production well #2 was replaced with a high efficiency 100hp motor in 2013, making it more

economical to operate. However, in order to be able to use the lower horsepower motor, one stage of the pump bowl had to be removed prior to switching to the smaller motor. In 2014, a combination of pressure swing adsorption oxygen generators and air compressors were replaced with a bulk liquid oxygen tank, and the total cost of the project was $109,000. While it is still early in operation of this new system, the early indications look good; the first year of use showed a reduction in both kilowatt hours and total cost. The FY14 kWh usage was 1.54 million kWh with a cost of $149,052, and the FY15 kWh usage was 1.43 million kWh with a cost of $129,755. This saved $19,297 in the first year of operation and resulted in a payback period of just over 5.5 years. Finally, in 2015, a geo-thermal heating unit was installed at a cost of $68,500 to dehumidify the building during the summer and help supplement the boiler. This change was more efficient than using a large boiler to accomplish the same task. During the relatively mild winters of 2015 and 2016, the geothermal unit was able to heat the entire building without use of the boiler. It is unlikely that this will be the norm for the facility, but it should still result in significant savings during milder winters. A summary of the payback periods for the energy audit at Harrietta State Fish Hatchery can be found in Table 3.

Table 3. *Financial findings for the energy audit at Harrietta State Fish Hatchery*

Electricity ECM	Energy Savings (kWh/yr)	Energy Savings (MMBtu/yr)	Annual Cost Savings	Cost to Replace	Payback (years)
Lighting	13,170	44.9	$1,154	$2,595	2.2
Occupancy Lighting	1,532	5.2	$126	$300	2.4
Refrigerator Replacement	1,168	4.0	$104	$450	4.3
Aeration Pump VFD	189,368	646.3	$16,854	$34,800	2.1
Well Pump VFD	87,258	297.8	$7,766	$16,000	2.1
Pump Upgrade	59,474	203.0	$5,293	$9,600	1.8
TOTAL	**351,970**	**1,201.3**	**$31,297**	**$63,745**	**2.0**

Propane ECM	Energy Savings (gal/yr)	Energy Savings (MMBtu/yr)	Annual Cost Savings	Cost to Replace	Payback (years)
Hot Water Pipe Insulation	29	3.0	$29	50	1.7
Water Heater Blanket	5	0.5	$5	$20	4.0
Total	**34**	**3.5**	**$34**	**$70**	**2.1**
TOTAL Savings		**1,204.8**	**$31,331**	**$63,815**	**2.0**

Energy Source	Energy Usage	Energy Usage (MMBtu/yr)	Energy Savings (MMBtu/yr)	Percent Energy Savings/yr	Saving ($/yr)
Electrical (kWh/yr)	1,456,415	4,969	1201.3	24.2%	$31,297
Propane (Gal/yr)	1,225	112	3	3.1%	$34
Total		**5,081.5**	**1,204.8**	**23.7%**	**$31,331**

Additionally, a summary of the identified ECM's for all three fish hatcheries can be found in Table 4, and a summary of the energy efficiency investments between 2010 and 2016 can be found in Table 5.

Table 4. *Summary of the identified energy efficiency measures*

State Fish Hatchery	Sq. Footage	Annual Energy Usage		Annual Energy Cost ($)	Annual Energy Savings		Annual Cost Savings ($)	Annual % Savings	Cost to Implement ($)	Payback (Years)
		kWh Equivalent	MMBtu Equivalent		kWh Equivalent	MMBtu Equivalent				
Wolf River Hatchery	70,600	1,744,882	5,954	$154,199	169,400	578	$14,687	9.71%	$35,720	2.43
Platte River Hatchery	51,525	8,846,034	30,183	$299,369	1,563,465	5,335	$47,592	17.67%	$107,240	2.25
Harrietta Hatchery	33,800	1,489,286	5,082	$125,946	353,103	1204.8	$31,331	23.71%	$63,815	2.04
Total	155,925	12,080,202	41,218	579,514	2,085,968	7,117	93,610	17.27%	206,775	2.21

Table 5. *Summary of energy efficiency investments*

Completed Energy Efficiency Investments							
	2010	2011	2012	2013	2014	2015	2016
Wolf River Hatchery			$5,000		$1,862	$4,700	$500
Platte River Hatchery		$500	$25,000				
Harrietta Hatchery	$27,000		$1,602	$12,000	$109,000	$68,500	

Environmental Findings

The energy audits at the three fish hatcheries also identified that there are many efficiency and renewable energy funding sources available. This includes the USDA-REAP and USDA-NRCS, as well as DOE and state energy agencies, university programs and extensions, utility companies, electric co-ops, and various state agencies.

Another result of the ECM's within an energy audit is a reduced carbon footprint in the form of reduced CO_2 and greenhouse gas emissions. The team at MSU was able to provide environmental evidence for all three fish hatcheries within their energy audits. The total estimated reduction in greenhouse gas production for the Wolf Lake State Fish Hatchery is 288,600 pounds per year, which is approximately 144 tons per year. The reduction in greenhouse gasses for the Platte River Fish Hatchery is about 1,050,000 pounds per year, which equates to 525 tons per year. Finally, the reduction in greenhouse gas production for the Harrietta State Fish Hatchery is 336,700 pounds per year, which is approximately 168 tons per year. Therefore, all of the ECM's within the energy audits reduced the total amount of greenhouse gas emissions by

approximately 1,675,000 pounds per year across all three fish hatcheries; this is roughly 837 tons annually. These values can be viewed graphically in Table 6.

Table 6. *Summary of the reduction in greenhouse gasses*

Greenhouse Gas Reduction		
	CO2 Equivalent	
	Lbs/Year	Tons/Year
Wolf River Hatchery	288,571.32	144.29
Platte River Hatchery	1,050,000.00	525.00
Harrietta Hatchery	336,685.53	168.34
Total	1,675,256.85	837.63

Client Feedback

Mr. Michael Jones is the maintenance supervisor at Wolf Lake State Fish Hatchery, and he was contacted for a personal interview about the recent energy audit that was conducted by Aluel Go's team at MSU. He stated that Mr. Go's contractor revisited the site multiple times to check up on the hatchery. He also stated, "the process was very thorough, and that the official report was very useful." Mr. Jones then said that the onsite visit took about five hours from start to finish for the large facility, and that Mr. Go counted every single light bulb! According to Mr. Jones, the fish hatchery had already implemented most of the ECM's, so the official report was more useful to convince the people in Lansing to fund the remaining ECM's. In his words, "it really helps us see where we will get the most bang for our bucks."

Additionally, client feedback was collected from Mr. Aaron Switzer. He is a northern area hatchery manager, and he oversees all of the major fish hatcheries in Michigan, including Platte River State Fish Hatchery and Harrietta State Fish Hatchery. He stated that the energy audits for these two facilities each took about half a day, and that Mr. Go was accompanied by an engineer who wrote the official report. Mr. Switzer also said, "moving forward, we will definitely consult the energy audit report." However, he did note that "these are large investments, which require a lot of money to implement. The hatchery only has certain funds available to make the changes."

At both the Harrietta and Platte Lake locations, several ECM's have already been implemented. One of the 50 year old motors has been replaced with a new VFD motor, and various incandescent light bulbs have been replaced with LED light bulbs. Mr. Switzer also stated that both hatcheries have been in the process of implementing changes over the past six years, which was reflected in the energy audit itself. According to Mr. Switzer, he had to gather,

organize, and format various gas and energy bills from the past five years, which was a lot of work on his part. “We had to not only manage our data, but also confirm that it was factual.” The combined efforts resulted in effective energy audits: so much so that the remaining three fish hatcheries in Michigan may receive energy audits themselves in the future.

Conclusions

An energy audit was conducted on three of the six major wildlife fisheries in Michigan, which documented the costs and savings from various ECM’s between 2010 and 2016. The developed ECM’s saved a calculated 9.71% annual savings for Wolf Lake State Fish Hatchery, 17.67% annual savings for the Platte River Fish Hatchery, and 23.71% annual savings for the Harrietta State Fish Hatchery. The total payback period for each hatchery was 2.43 years, 2.25 years, and 2.04 years, respectively. These low payback periods denote that the recommended ECM’s are advantageous. The developed ECM’s also resulted in an annual reduction of 144 tons of CO2 for Wolf Lake State Fish Hatchery, 525 tons of CO2 for Platte River Fish Hatchery, and 168 tons of CO2 for Harrietta State Fish Hatchery. This positively impacts the welfare of Michigan’s crops, animals, and ecosystems, which results in increased tourism to Michigan.

Requesting an Energy Audit

One may ask, “how can I sign up for an energy audit?” It is a simple process, but a few steps need to be completed before requesting an energy audit. First, one must request a rate analysis from their utilities provider. Next, they need to call their energy supplier. Then, they should revisit any line upgrade or expansion estimates. After that, one must call various funding sources to see what financial options are available. Finally, they should contact another source that is knowledgeable about the energy audit process to get an idea about what is entailed. For example, they could ask a fellow farmer, facility manager, or even farm.org. After all of that is complete, it is time to call for an energy audit!