Energy Efficiency Strategies for Rural Communities

Energy Efficiency Advisor

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MRWA

Minnesota Rural Water Association

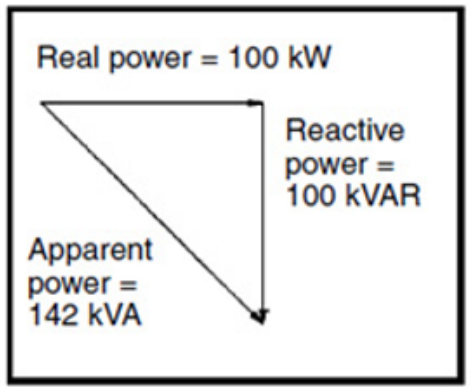
Water you thinking?

- Energy costs money.
- Search for energy savings and you'll find money!
- Energy Efficiency doesn't sound sexy but money gets everyone's attention.

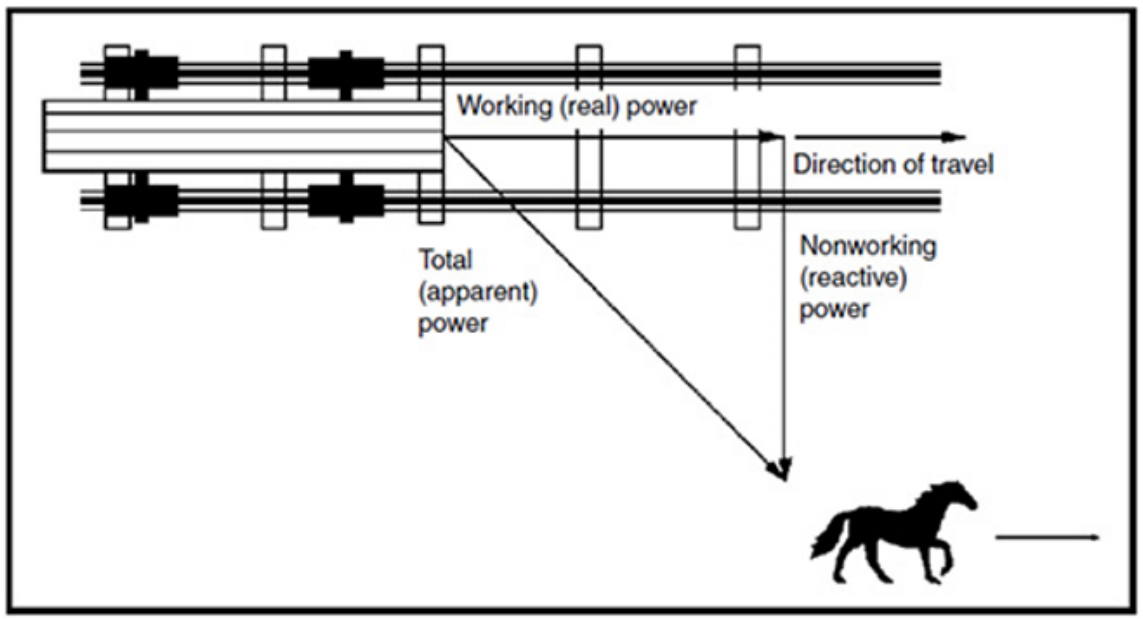
Significant cost

- Electricity-use accounts for 25–40 percent of the operating budgets for wastewater utilities and approximately 80 percent of drinking water costs.

The power triangle



Real power = 100 kW
and
Apparent power = 142 kVA
then
Power Factor = 100/142 = 0.70 or 70%.



(Courtesy U.S. Dept. of Energy)

- As indicated in the illustration, as a power factor becomes lower (more kVAR) the horse is pushed further off to the side of the tracks. This causes the horse (utility generation) to work harder while still only producing the same amount of work (pulling the cart down the track).
- The low power factor causes the entire system of both generation and delivery to become inefficient.

Beer: Real, active, useful, resistive. **Foam:** Reactive, non-working, wasted. **Demand:** Total, apparent power.

Making sense of power factor: The beer analogy

[Power quality](), [101 Learning]()

FLUKE

Water/WW Billing.
Same Power Company, Same City

Water Treatment Facility							
12 Month Billing	Bill Days	Avg Temp	Inches Precip.*	kWh	Power Factor	Total	Tot$/kWh
Annual Total	365		27.87	91,000		$15,107.12	
Monthly Average	30.41667	43	2.32	7,583	79.2	$1,258.93	**$0.167**

Wastewater Treatment Facility							
12 Month Billing	Bill Days	Avg Temp	Inches Precip.*	kWh	Power Factor	Total	Tot$/kWh
Annual Total	365		27.87	471,743		$41,003.74	
Monthly Average	30.4	42	2.32	39,312	0.7602	$3,416.98	**$0.0873**

Electric Rates

- **General Service Rate** (water plant) includes the power factor. ($0.167) **16.7 cents** blended cost.
- **Municipal Pumping Rate** (wastewater plant) does not include the power factor. ($0.876) **8.76 cents** blended cost.
- You are paying a power factor penalty if the billed demand is higher than the metered demand.
- $15,107.12 total annual electric at the water plant.
- $1,008.11 Power Factor Penalty
- 7% penalty. Correct the Power Factor with capacitors or variable frequency drives.

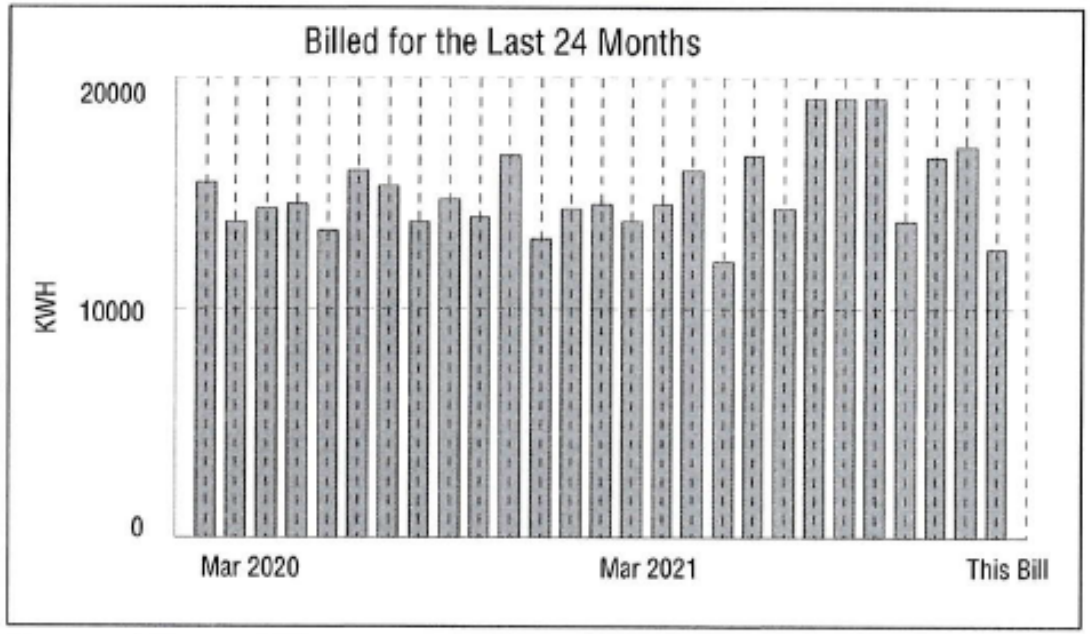
Month	Actual kW	Power Factor	Billed kW	Additional kW	Penalty per kW	Total Power Factor Penalty
October-17	0	0.00%	0	0	$ 10.71	$ -
November-17	49	80.36%	55	6	$ 10.71	$ 64.26
December-17	49	81.32%	54	5	$ 10.71	$ 53.55
January-18	49	81.51%	54	5	$ 10.71	$ 53.55
February-18	49	82.12%	53	5	$ 10.71	$ 53.55
March-18	50	79.49%	56	7	$ 10.71	$ 74.97
April-18	50	78.17%	58	8	$ 10.71	$ 85.68
May-18	47	76.02%	56	9	$ 10.71	$ 96.39
June-18	47	76.58%	55	8	$ 15.25	$ 122.00
July-18	48	78.09%	55	7	$ 15.25	$ 106.75
August-18	48	78.01%	55	7	$ 15.25	$ 106.75
September-18	48	78.68%	55	7	$ 15.25	$ 106.75

	11 Month Power Factor Penalty:	***$ 924.20***
Power Factor Target: 90%	**Annuallized Power Factor Penalty:**	***$ 1,008.22***

Xcel Energy

The demand charge is applied to each month's billing kW, which is the maximum 15-minutes average actual kW demand measured during the billing month, rounded to the nearest whole number. Billing demand is adjusted upward if the power factor shown onthe bill is below 90 percent, by dividing actual kW by the power factor and multiplying by 90 percent.

Measured Demand=23. Billed Demand=27. Assume 23 gallons of gasoline pumped while paying for 27 gallons!



Measured Demand 23
Billed Demand 27
Power Factor 76.8523

Adjusted Demand 27

Service Charge	12.00
Demand Charge 27 kW @ $6.50	175.50
Energy Charge 12,650.496 kWh @ $0.06054	765.86
Resource Adjustment	369.45
Interim Rate Adjustment 14.23%	184.61
Low-Income Affordability Program Surcharge	1.55
Renewable Adjustment 12,650.496 kWh @ $0.00178	22.52
Transmission Adjustment 12,650.496 kWh @ $0.00318	40.23
Solar Energy Adjustment 12,650.496 kWh @ $-0.00006	-0.76
Solar Renewable Adjustment 12,650.496 kWh @ $0.00155	19.61
Total charge this period	**1,590.57**

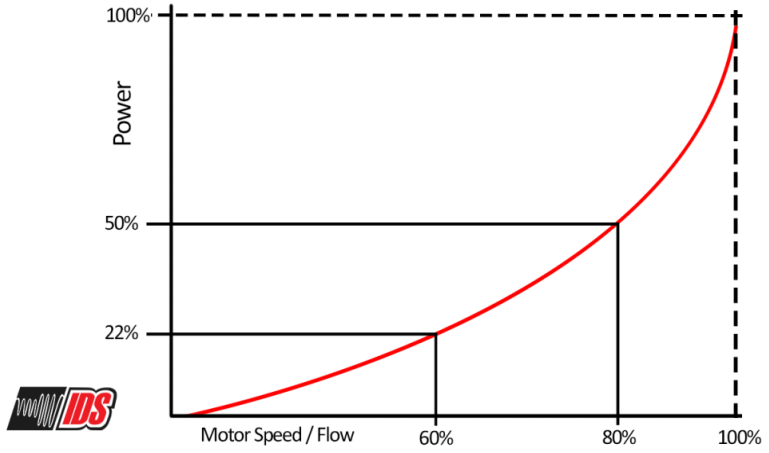
Rate Comparison: Four 200 HP air blowers

		12 month total	$ Savings	**% Savings**
Rate 871	Existing rate	$282,906.67		
Rate 603	LSG Secondary	$258,862.93	$24,043.74	8.5
Rate 611	Time of Day	$252,171.71	$30,734.96	10.9
Rate 708	Time of Use	$251,080.13	$31,826.54	**11.3**

Rate 871	Existing rate	$282,906.67
Rate 708	Time of Use	$251,080.13
	Annual Savings	**$31,826.54**

Affinity Laws for variable frequency drives.

- **Cube Law Explained**
- The power is proportional to the speed cubed. Since it is the power that costs the money the graph shows what it looks like in practice.
- And the sums look like this for slowing down a pump by 20% …. 80% speed cubed, .8x.8x.8.= .51



“Cube Law Explained” was copied from Inverter Drive Systems LTD.
https://www.inverterdrivesystems.com/cube-law/

Pumps have a defined operating range

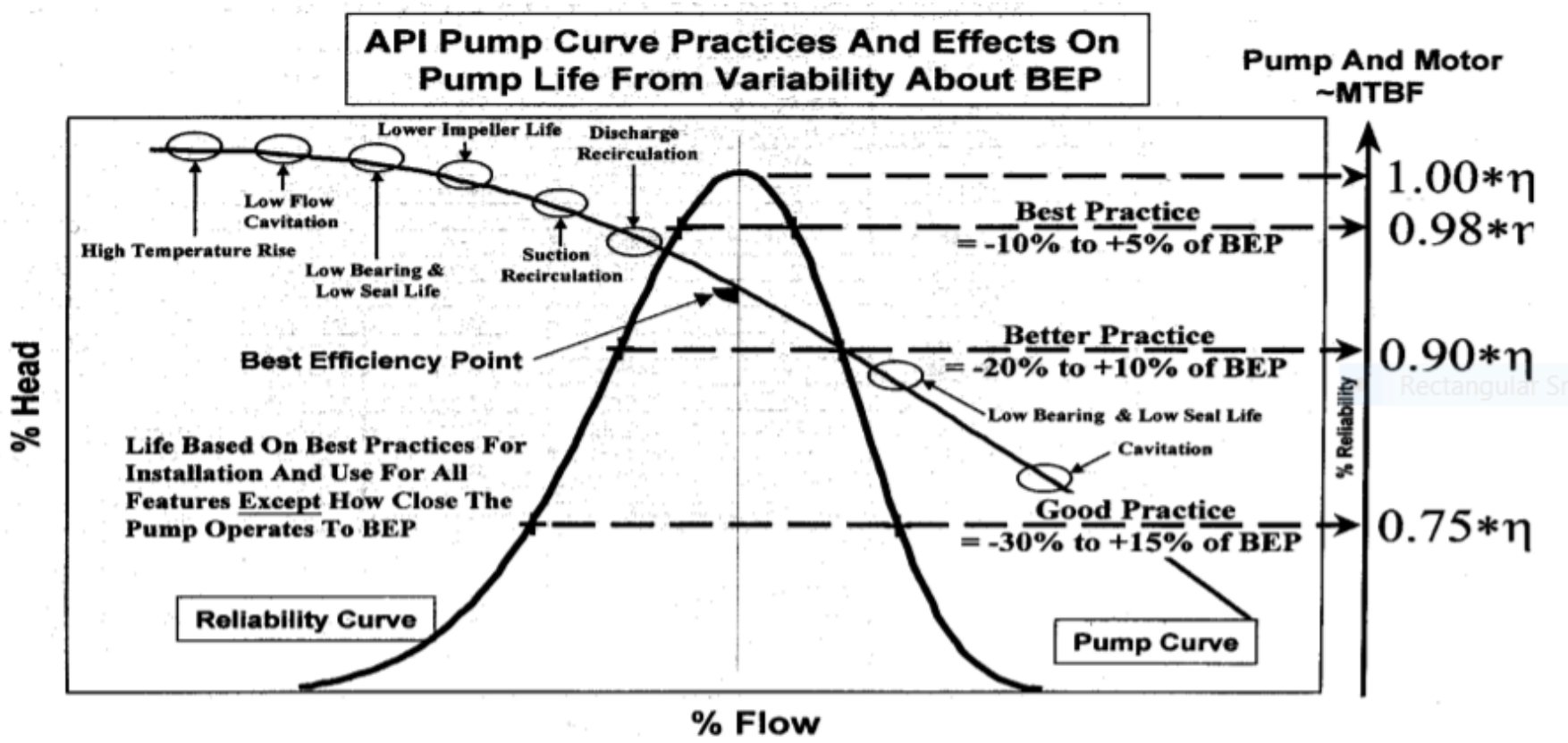


Figure 1: Barringer-Nelson curves show reliability impact of operation away from BEP (Courtesy of Paul Barringer, www.barringer1.com)

Old pump with 30HP low efficiency motor.

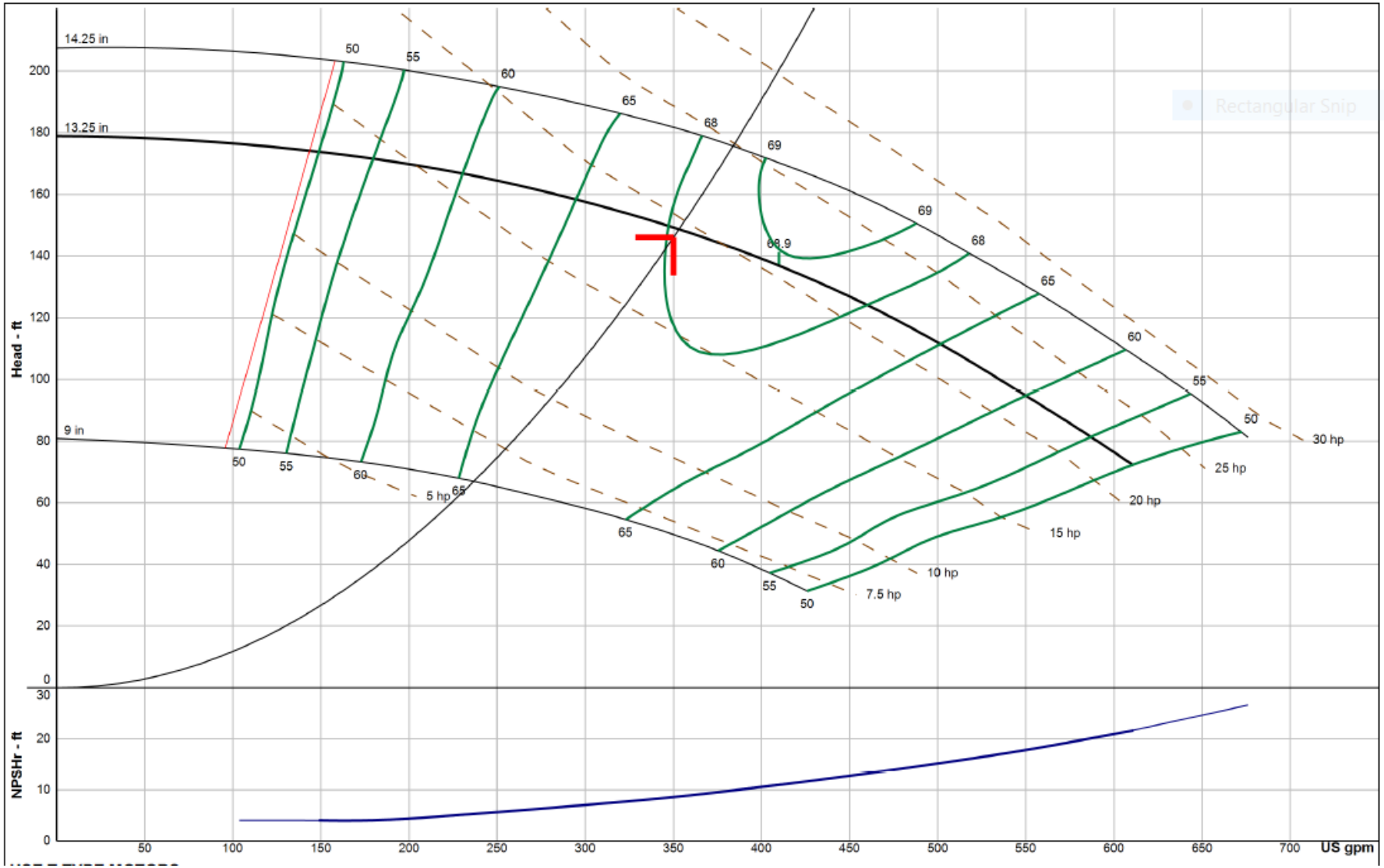
New pump with high-efficiency 20HP motor

Weinman®-Deming® split case pumps meet design criteria of ASTM, HI, ANSI AISI, SAE and ASME.

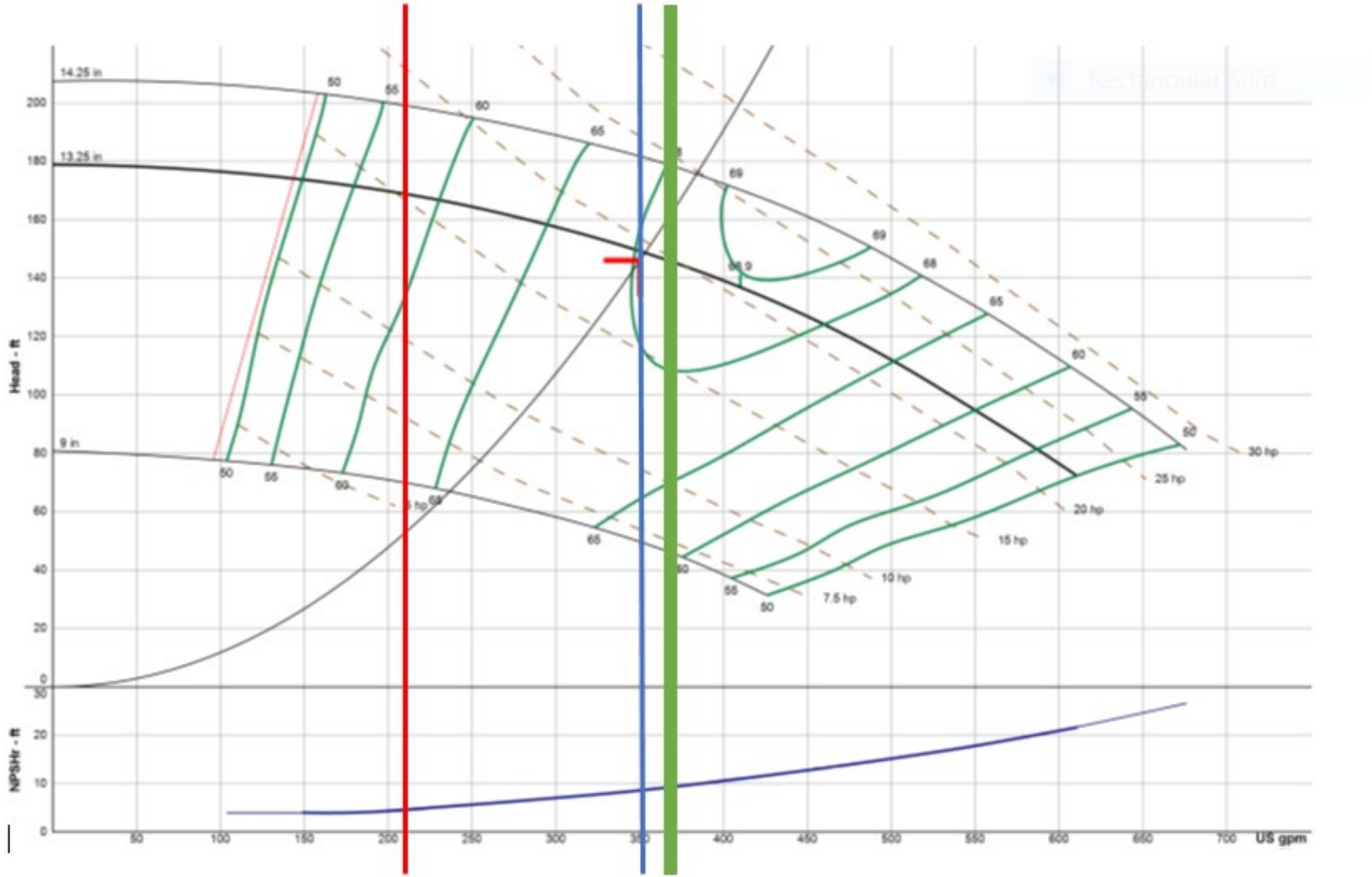
NSF

Certified to NSF/ANSI 61 & 372

Pump curve and system curve



Pump curve plotted: 215gpm, 350gpm, 365gpm



VFD Adjustments 30% Energy Savings

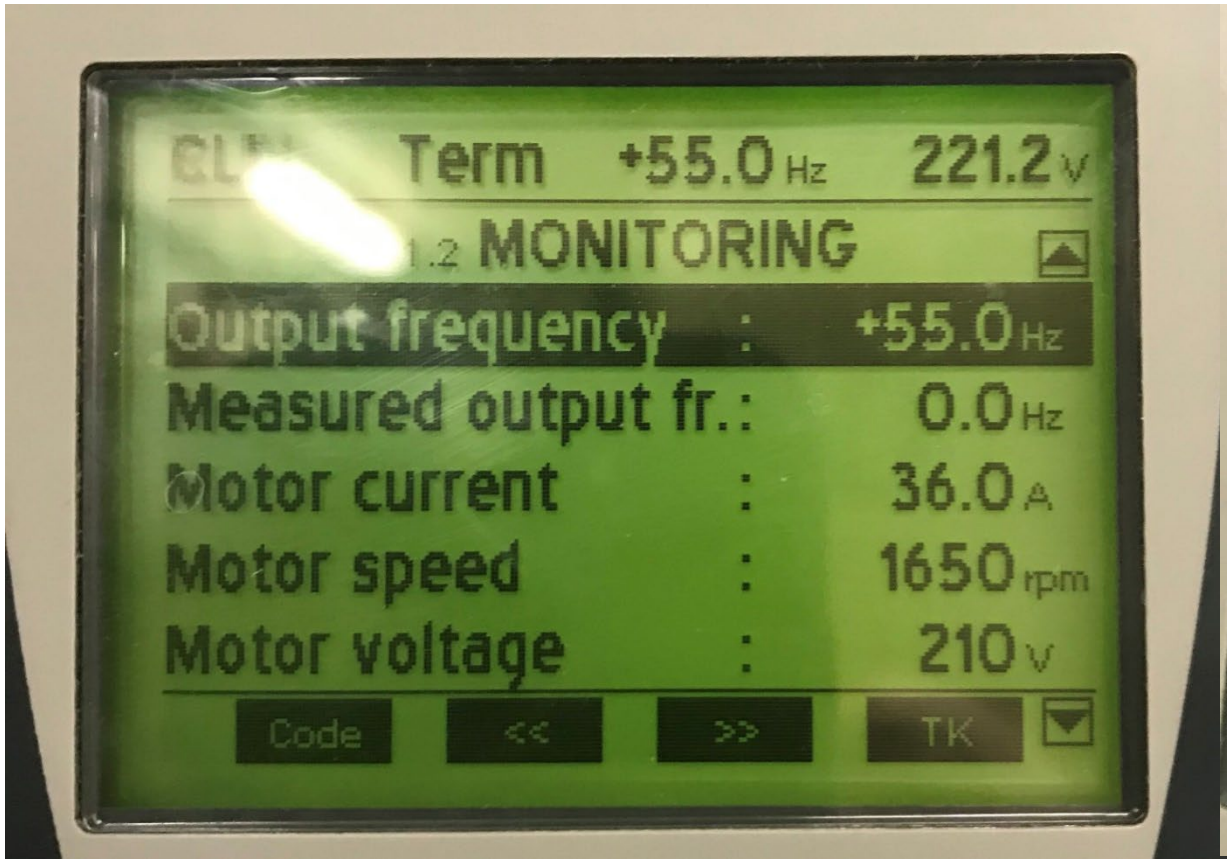
		Hertz	Amps	Volts DC	Output voltage	GPM	PSI	
6/13/2019	Old pump	**46.8**	**74**	323	181	**350**	57.4	**4.7 gallons per amp**
6/9/2020	New pump	**47.5**	**44.5**	319	184	**215**	57.2	**4.8 gallons per amp**
9/14/2020	New pump	**49.3**	**52.8**	320	196	**364**	57.7	**6.9 gallons per amp**

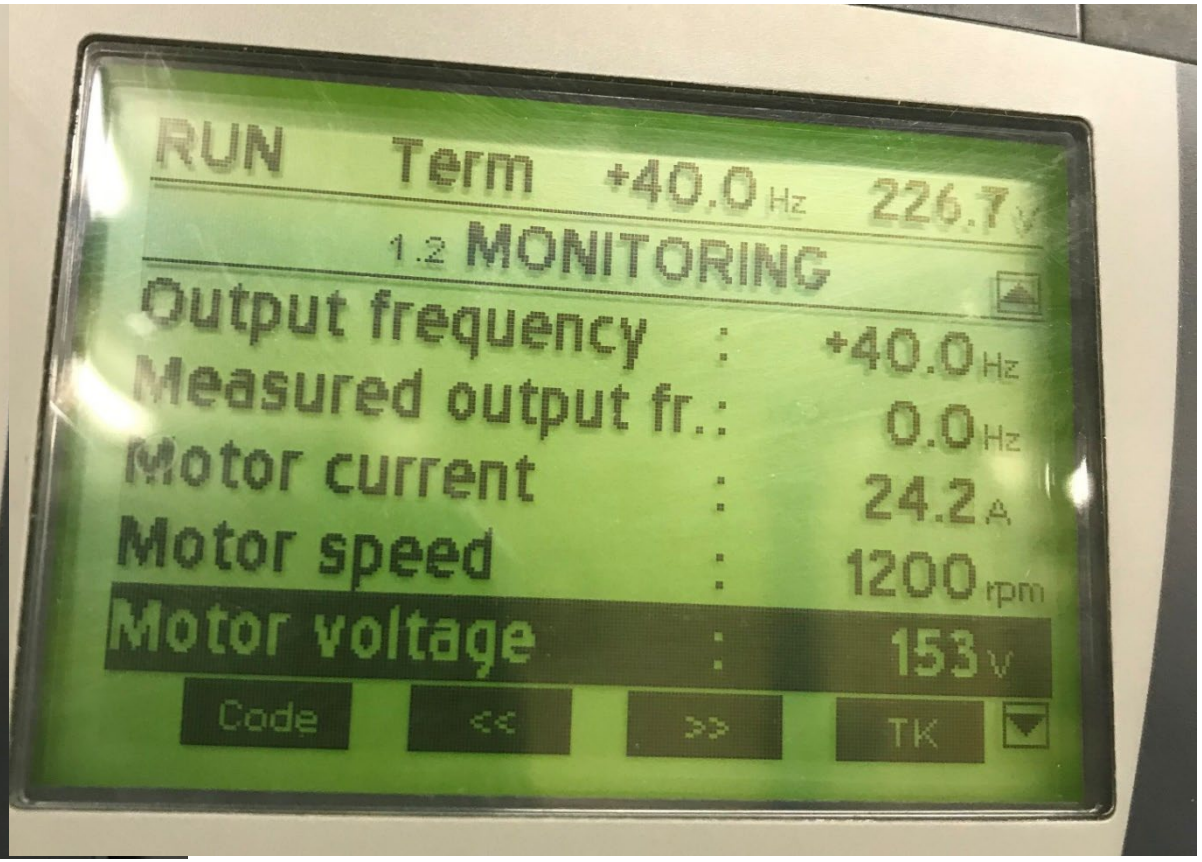
City of Happy Place			W_____ Treatment Facility					
Equip	Date	Amps	Output voltage	Hertz	KW	GPM	Discharge PSI	Gallons per KW
								GPM/KW
								#DIV/0!
								#DIV/0!
								#DIV/0!

Water plant

Edge of pump curve, 60 hertz required

VFD and Valve adjustments. 30% savings.





Decreased pressure creates energy savings. VFDs ordered.

Equipment ID:	**High Service Pump #1**				GPM/KW
Date	Hertz	Valve position	GPM	KW	**GPM per KW**
5/23/2022	60	throttled	189	10.687	**17.7**
5/23/2022	60	Open	342	12.631	**27.1**
			44.7%	15.4%	**34.7%**

Equipment ID:	**High Service Pump #2**				GPM/KW
Date	Hertz	Valve position	GPM	KW	**GPM per KW**
5/23/2022	60	throttled	187	10.46	**17.9**
5/23/2022	60	Open	335	12.12	**27.6**
			44.2%	13.7%	**35.1%**

VFDs and Sheaves

ABB drive, 30 HP air blower.

Sheave size is critical on belt-driven equipment

- 60 hertz = 113.1 amps.
- 45 hertz = 101 amps.
- 40 hertz = 100 amps.
- 35 hertz = 103 amps.
- The 40HP motor has 9.2” sheave, blower had a 9.75” sheave. 1,765 motor rpm x 9.2 / 9.75 = 1,665 blower rpm. New blower sheave = 12”: 1,765 motor rpm x 9.2 / 12 = 1,353 blower rpm at 60 HZ.

Follow-up Assessment

- Initial assessment: Increase the blower sheave size on the aeration blower. Install a VFD on the digester air blower.
- Follow-up assessment: Digester blower operating at 35 hertz. Determined that sheaves need to be changed on the digester blower.

  33.7% Savings

	Pre Assessment	Post Assessment	Savings
Total Energy Consumption (kWh)	443320	294130	149190
Current energy rate ($)	0.089164	0.089164	0
Total Energy Costs ($)	$39,528.18	$26,225.83	$13,302.36

Air blower specifications

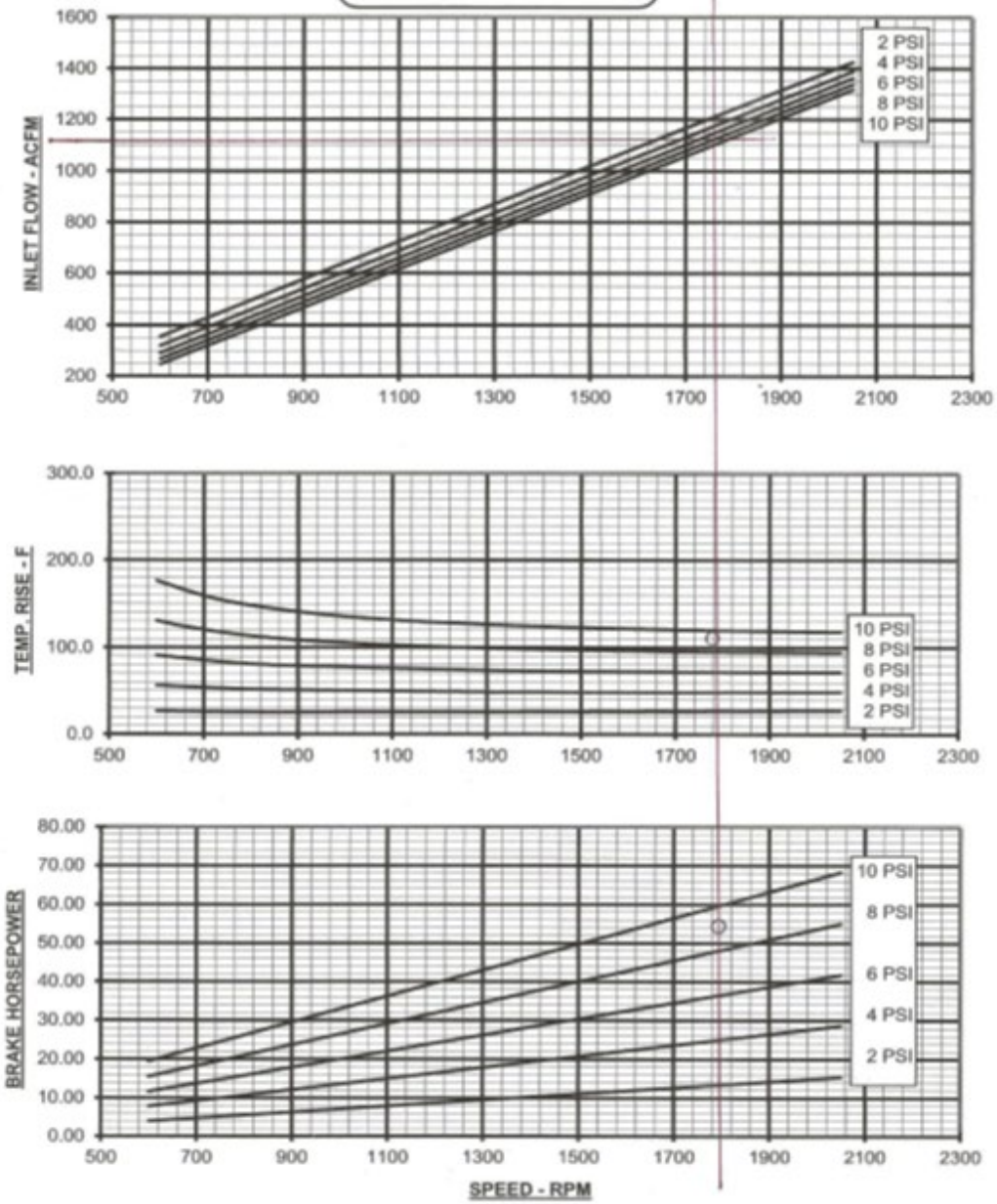
- Must always operate between the minimum and maximum speed.
- Program the minimum speed into the VFD.
- Air flow must be enough for cooling.
- Speed must be fast enough to splash enough oil for lubrication.

Howden

WWW.HOWDEN.COM

PERFORMANCE BASED ON AIR, INLET AT 14.7 PSIA & 68°F
CURVES GENERATED: DEC-2004

PRESSURE PERFORMANCE
FRAME 711 U-RAI
MAX. PRESSURE RISE = 10 PSI
MAX. SPEED = 2050 RPM



15 HP air blower

VFD Savings on Air Blowers, 29% Plant Savings. 2 year ROI.

2018 Wastewater Treatment Facility						
Billing From	Billing To	Bill Days	kWh	Power Factor	Total	Tot$/kWh
6/10/2018	7/10/2018	30	9,240	78.4	$890.17	$0.0963
7/10/2018	8/10/2018	31	9,480	78.7	$914.88	$0.0965
8/10/2018	9/10/2018	31	9,480	80.6	$922.02	$0.0973
3 month Total		92	28,200		$2,727.07	
Monthly Average		**31**	**9,400**	**79.2**	**$909.02**	**$0.0967**

2020 Wastewater Treatment Facility						
Billing From	Billing To	Bill Days	kWh	Power Factor	Total	Tot$/kWh
6/10/2020	7/10/2020	30	6,480	87.4	$637.18	$0.0983
7/10/2020	8/10/2020	31	6,840	87.2	$693.65	$0.1014
8/10/2020	9/10/2020	31	6,720	86.8	$630.88	$0.0939
3 month Total		92	20,040		$1,961.71	
Monthly Average		**31**	**6,680**	**87.1**	**$653.90**	**$0.0979**

VFD, 15 HP submersible well.

55% reduction, Grove City, MN. Installed VFD, opened valve.

Follow up assessment			
	Pre Assessment	Post Assessment	Savings
Total Energy Consumption (kWh)	77,787.47	34,871.76	42,915.71
Current energy rate ($)	0.11879	0.11879	0
Total Energy Costs ($)	$9,240.37	$4,142.42	$5,097.96

Oxidation Ditch facility

Project Item	Recommended Energy Conservation Measure Description	Annual Energy Savings (kWh)	Annual Cost Savings ($)	Estimated Cost of Improvement ($)	Rebate Total ($)	Payback (Years)	Ref Pages
Wastewater Plant	Reduce the water level in the ditches and reduce the ramp speed on the VFDs for the brush rotors.	55,123	$5,142.96	$0.00	$0.00	0.00	5-6
Chemical cost	Improve Bio-Phosphorus removal with anoxic zones	0	$4,289.00	$0.00	$0.00	0.00	7
Effluent blower	Use the start/stop function and open the discharge valves	16466	$1,536.30	$0.00	$0.00	0.00	7
	Totals	71589	$10,968.26	$0.00			

Efficient travel

Questions?

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