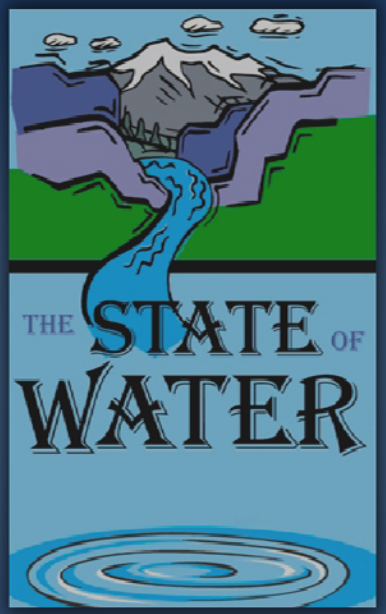
Kennedy/Jenks Consultants

Engineers & Scientists

Addressing Issues with Power Supplies and Variable Speed Drives

James Krumwied



Presentation Overview

- Issues to discuss:
  - Do I really need a VFD?
  - Medium voltage vs. low voltage, do I have a choice?
  - 6 pulse, 18 pulse, 24 pulse, what is the difference and why do I care?
  - VFD's can cause resonance issues, how can I avoid them?

Do I Really Need a VFD?

- Advantages
  - Potential Energy Savings
  - Improved System Control – Operational Flexibility
- Disadvantages
  - Higher Capital Cost
  - Installation Issues (Noise, Heat Rejection)
  - Structural Resonance Issues
  - Harmonic Issues

Estimating Cost Savings

- Pump Affinity Laws

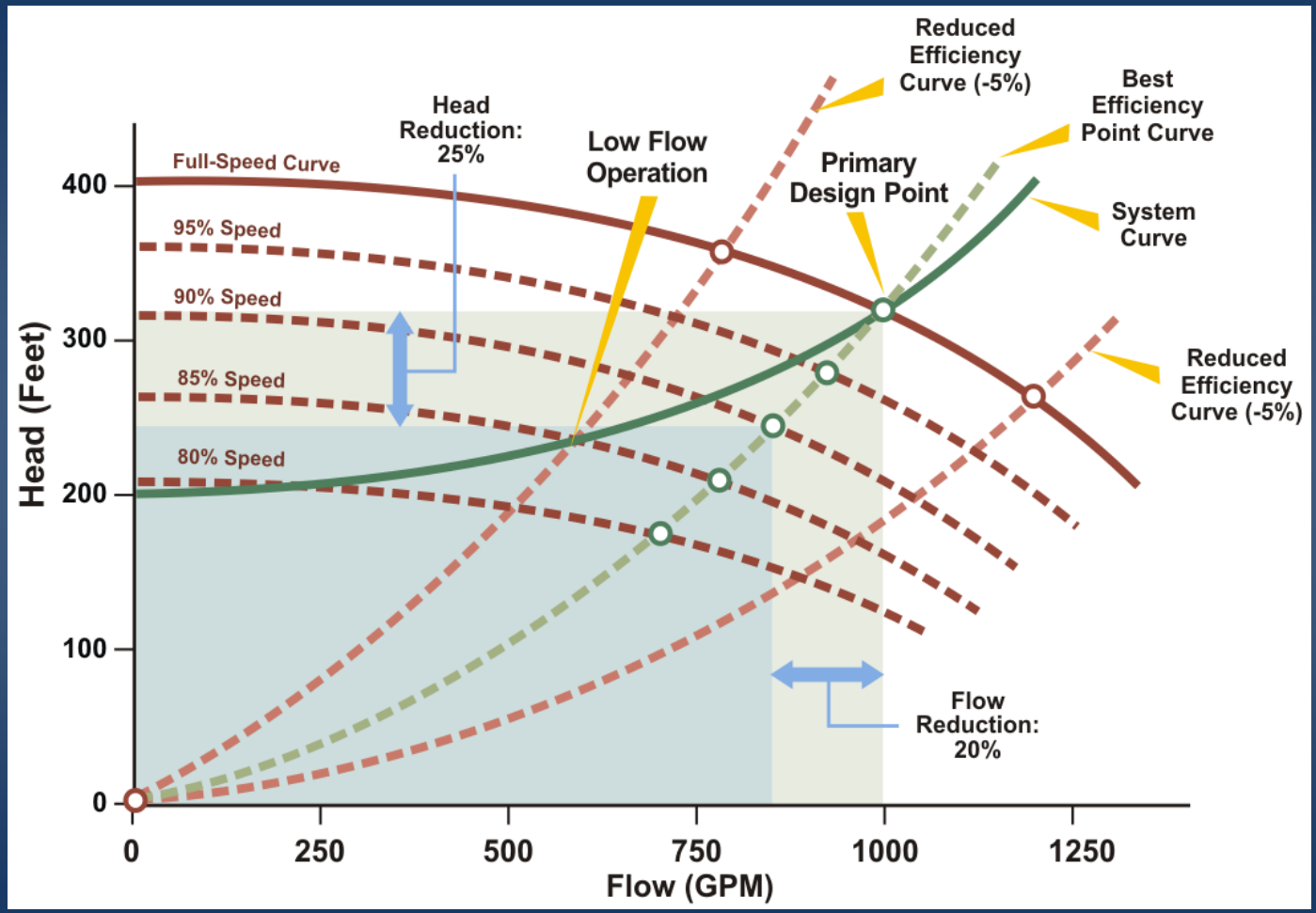
$$Q(\mathit{flow}) \propto N(RPM)$$

$$H(Head) \propto N(RPM)^2$$

$$Hp(Horsepower) \propto N(RPM)^3$$

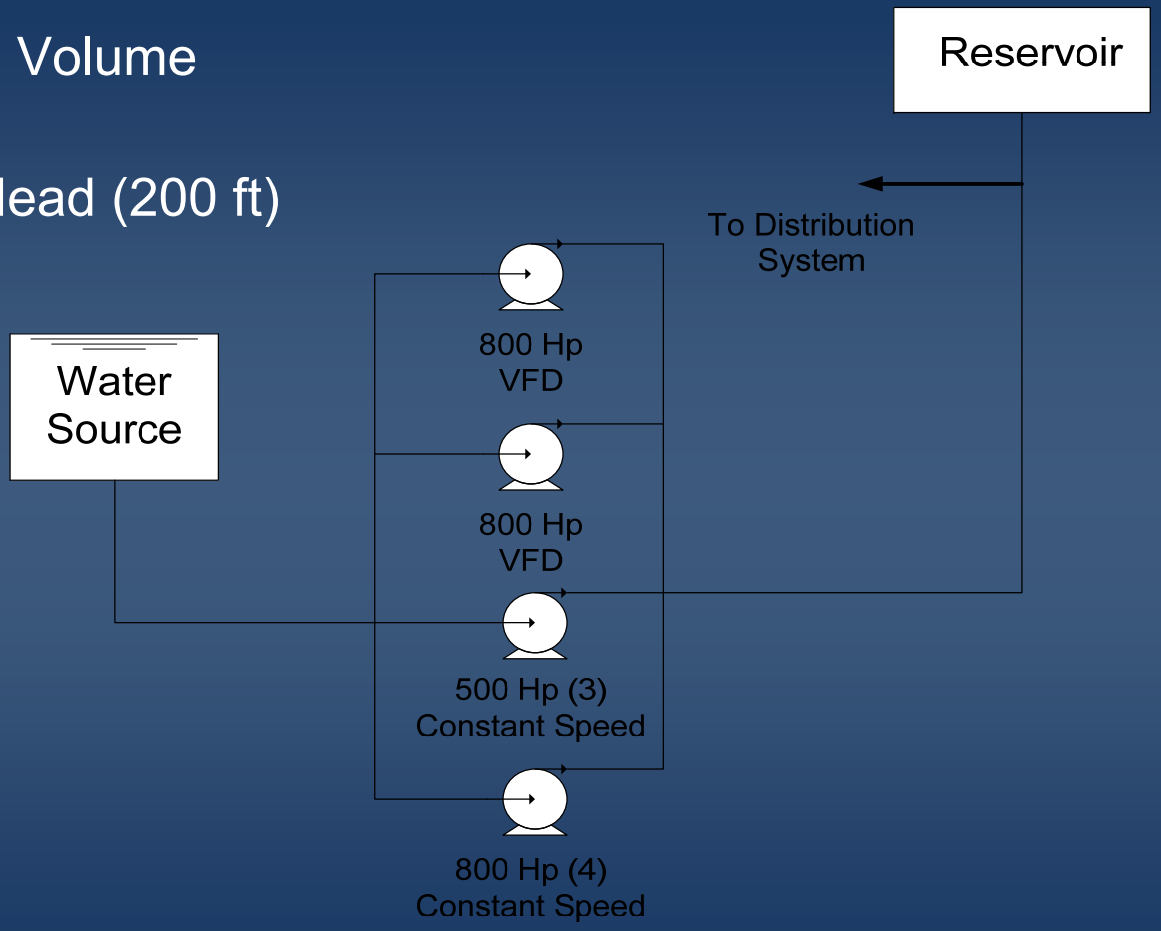
20% reduction in speed can result in a 51% reduction in power consumption, (sort of)

VFD Operation



Sample Water Distribution System

- Sample High Volume System
- High Static Head (200 ft)

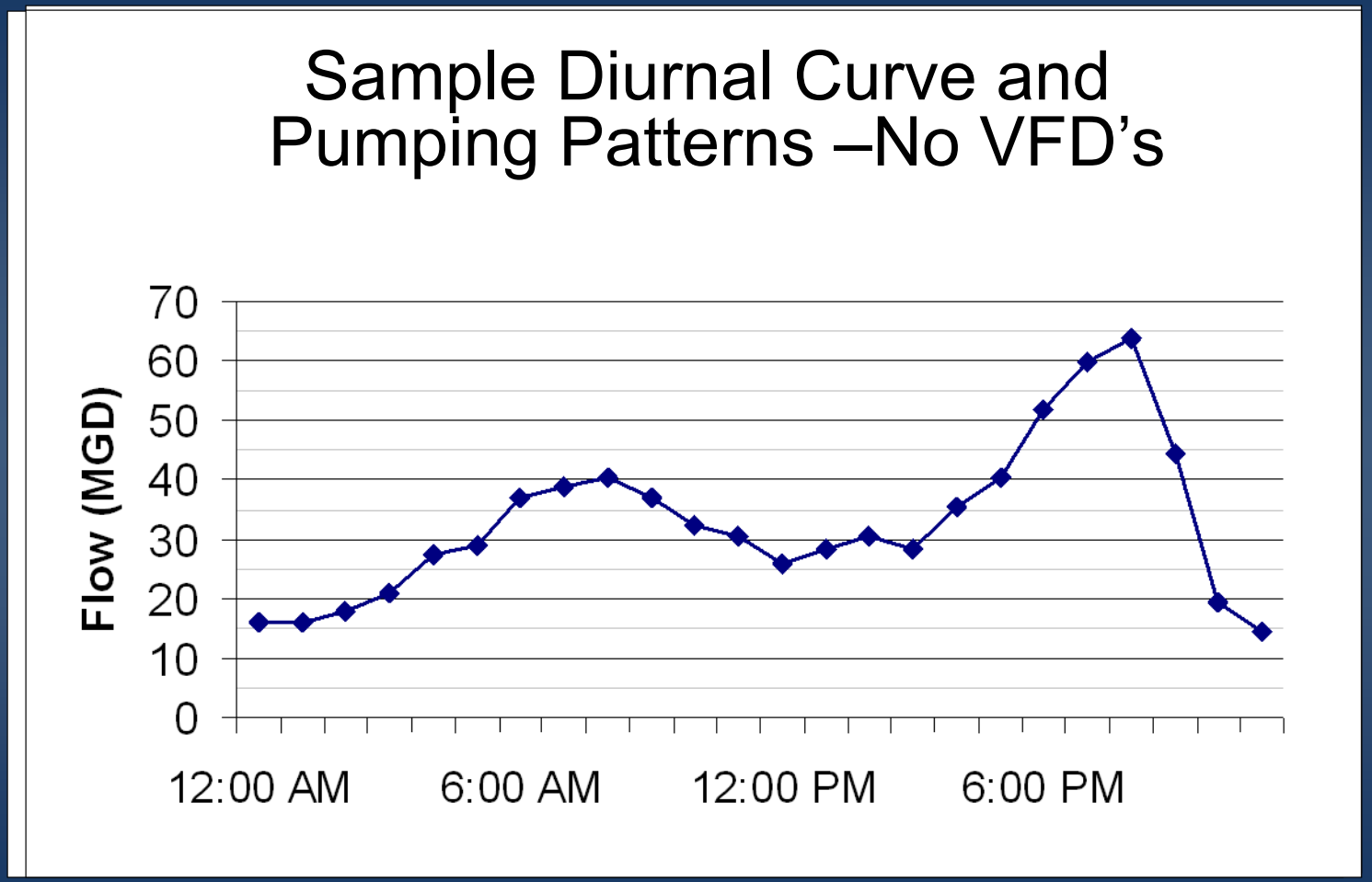


Diurnal Curve and Pumping

Blue- Demand

Pink- Pumping

Green- Average Demand

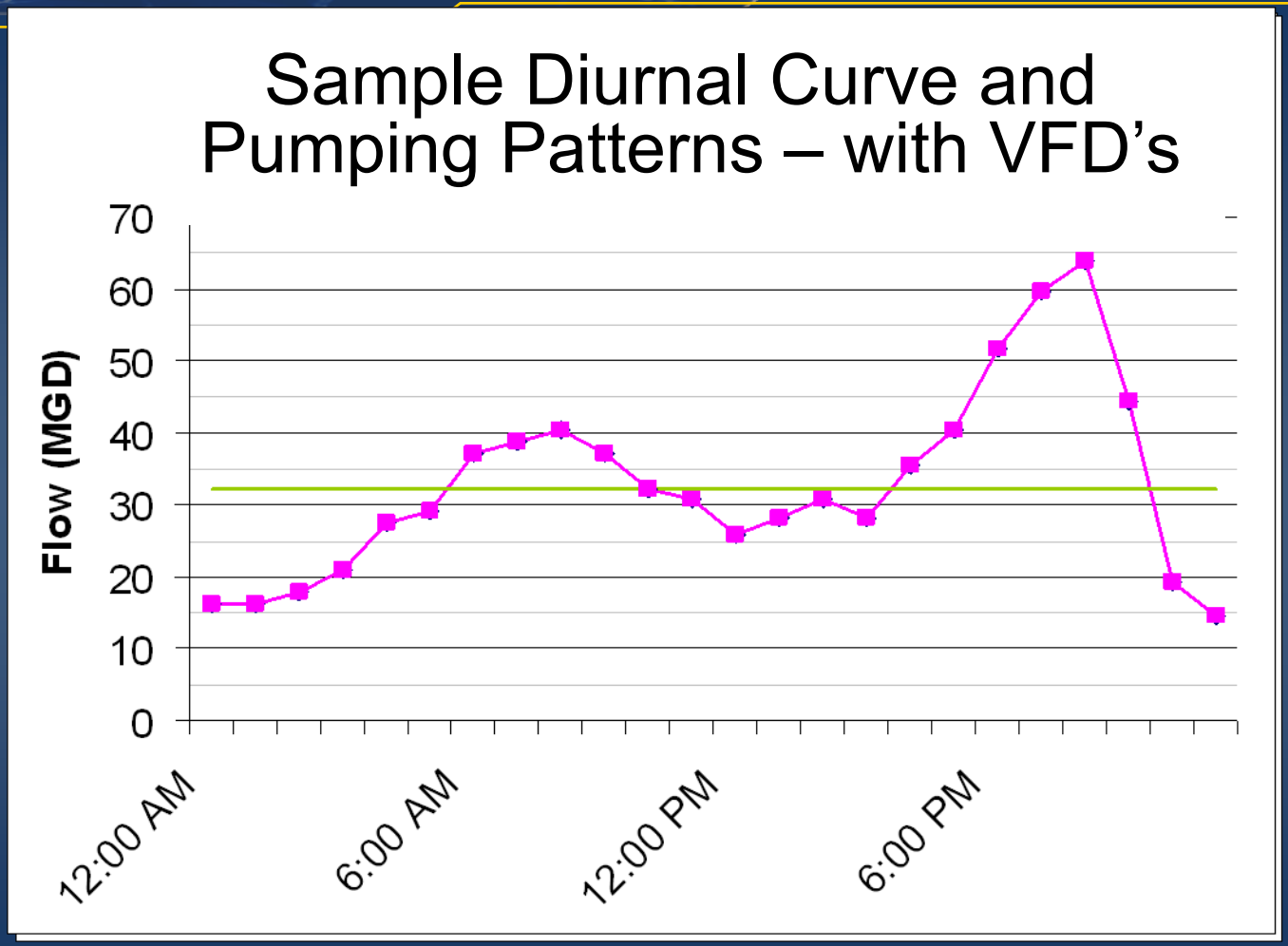


Diurnal Curve With a VFD

Blue-
Demand

Pink-
Pumping

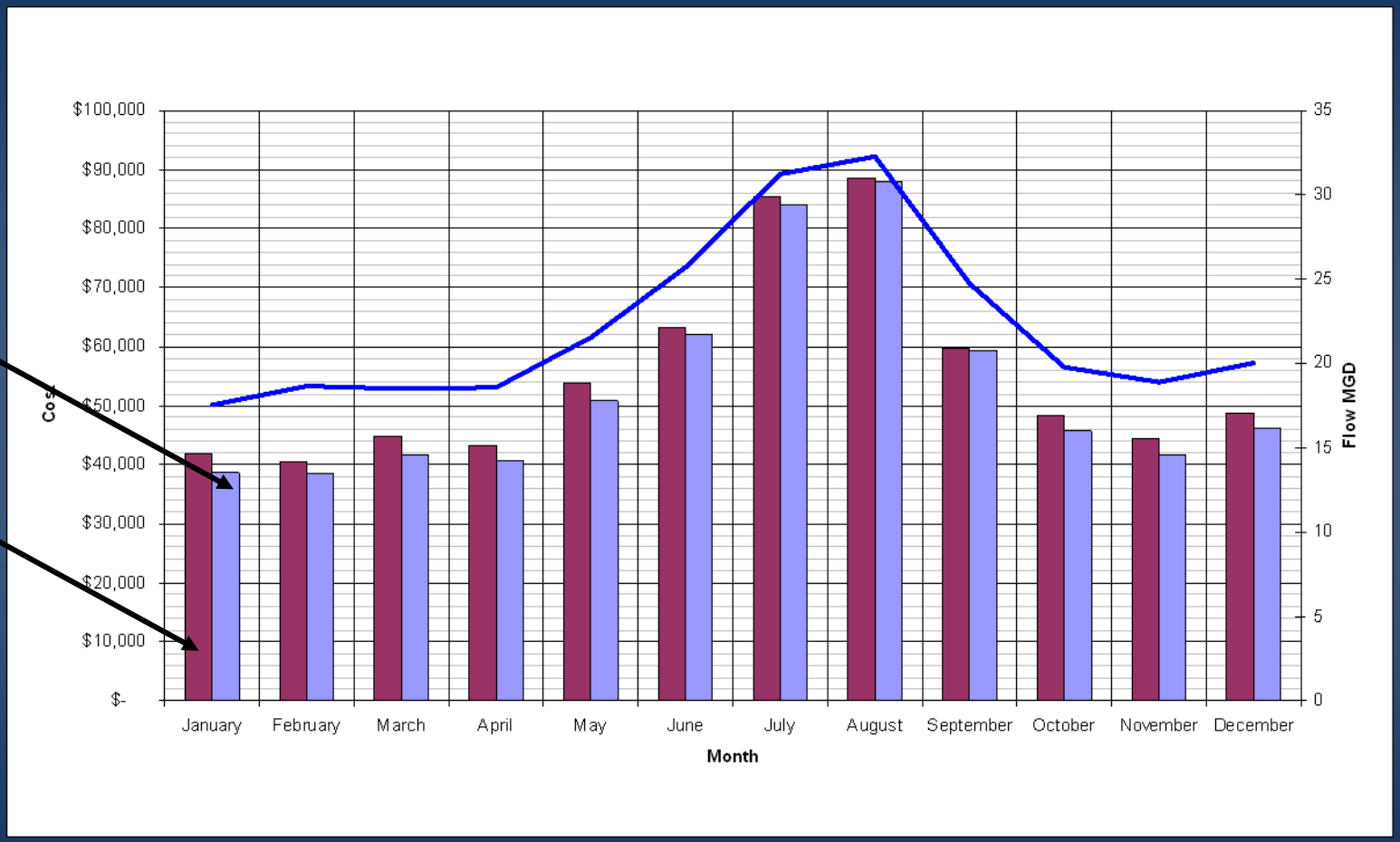
Green-
Average
Demand



Hypothetical System Monthly Cost

2-VFD's

No VFD's



Life Cycle Analysis

Capital Costs	Baseline - No VFD's	Two VFD's
Estimated Bid Price	**$ 417,000**	**$ 964,000**
Total Project Cost	**$ 554,000**	**$ 1,283,000**
Capital Difference From Baseline	N/A	$ (729,000)
Projected 2010 Annual Totals		
Average Power Effectiveness (kW/mgd)	45.8	42.9
Pumping Energy Costs	$ 503,000	$ 471,000
Cost/Savings From Baseline	N/A	$ 33,000
Operating Costs - NPV		
Pumping Costs	$ 9,385,000	$ 8,778,000
Equipment Maintenance	$ 102,000	$ 214,000
Net Operating Cost	**$ 9,487,000**	**$ 8,991,000**
Operating Difference from Baseline		$ 495,000
Present Worth		
Capital	$ 554,000	$ 1,283,000
Salvage	$ (42,000)	$ (83,000)
Operating	$ 9,487,000	$ 8,991,000
Total Present Worth	**$ 9,999,000**	**$ 10,191,000**
Total LCC Savings From Baseline	**N/A**	**$ (192,000)**

Medium Voltage vs Low Voltage

- Drives Between 500-1000 Hp
- Drives Available at 480V (Low Voltage) and 2400V or 4160V (Medium Voltage)
- Things to Consider
  - Available Voltage
  - Available Space
  - Ability to Maintain

STATE WATER

Medium Voltage vs Low Voltage

- Low Voltage Advantages
  - Lower Cost Equipment
  - Easier Maintenance
- Disadvantages
  - Larger Equipment
  - Larger, Expensive Cabling
  - May Require an Additional Transformer

Cost Comparison

- Low Voltage
  - 400 Hp - $70K
  - 600 Hp - $106K
  - 800 Hp - $150K
- Cabling (800 Hp)
  - $25/Linear Foot
- Additional Transformer
  - $50K-$100K

- Medium Voltage
  - 400 Hp - $150 K
  - 600 Hp - $190 K
  - 800 Hp - $210 K
- Cabling (800 Hp)
  - $5/Linear Foot
- List prices for both may be higher

6 Pulse, 18 Pulse, or 24 Pulse

- Most drives available are Pulse Width Modulating
- In basic terms, higher pulse = cleaner power
- 6 Pulse is not a smooth as a 24 Pulse
- 6 Pulse is less expensive, but may require filtering
- IEEE 519 is not straight forward, can be a judgment call, discuss with utility.
- Footprint issue, can make the drive 50% larger

VFD Resonance Issues

- Beware of Adding a VFD to an Existing Pump
- The pump may have resonance issues at required operating frequencies
- Pump head and shaft should be considered

Questions?